FINAL
ENVIRONMENTAL STATEMENT

# ARKANSAS - RED RIVER BASIN, CHLORIDE CONTROL
# TEXAS, OKLAHOMA, AND KANSAS
# (RED RIVER BASIN)

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, TULSA DISTRICT
TULSA, OKLAHOMA 74102

JULY 1976

## SUMMARY SHEET

## ARKANSAS-RED RIVER BASIN CHLORIDE CONTROL, TEXAS, AND KANSAS (RED RIVER BASIN)

( ) Draft (X) Final Environmental Statement

Responsible Office: US Army Engineer District
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1. Name of Action:

Administrative (X) Legislative ( )

2. Description of Action: Construction of five low-flow dams, three brine dams, three subsurface cut-off walls, two shallow well collection systems, one well point collection system, and installation of associated pumps and pipelines for collecting, transporting, and storing brine-laden waters. These facilities will be located in Cottle, Foard, King, Knox, Hall, Childress, Collingsworth Counties, Texas, and Beckham, Greer, and Harmon Counties, Oklahoma. Future development would require three subsurface cut-off walls with shallow well collection in Frisco and Hall Counties and an additional shallow well collection system in Cottle County.

3. Adverse Environmental Effects: There will be a total of 11,900 acres of land eventually inundated with brine, and 12,220 acres with future development. The brine will cause a progressive degradation of the soil and vegetation, causing displacement of land animals. The aesthetic conditions surrounding the brine pools may be regarded by some as an encroachment upon a wild landscape by manmade features. The removal of the brine from behind the low-flow dams will produce drier conditions during low-flow periods for some distance downstream.

4. Alternatives: Proposed project, desalination, nuclear cavitation, subsurface injection of the brine, disposal of the brines by pipeline to the Gulf of Mexico, collection and off-stream evaporation pond disposal, advanced waste treatment, dilution by diversion waters, dilution with ground water, Ruhr type disposal method, disposal by irrigation, interception of subsurface brine springs, and no action.

5. Comments Were Received From:

Federal Agencies

Advisory Council on Historic Preservation
Department of Transportation (Oklahoma)
Department of Health, Education and Welfare
US Department of Commerce
Department of Housing and Urban Development
Department of Transportation (Texas)

Federal Agencies (continued)

Soil Conservation Service
US Forest Service
Department of the Interior
Environmental Protection Agency

State Agencies

Oklahoma Department of Wildlife Conservation
State Grant-In-Aid Clearinghouse (Oklahoma)
Oklahoma Archeological Survey
Oklahoma Historical Society
Texas Department of Health Resources
Texas Water Quality Board
Texas Parks and Wildlife Department

6. Draft statement to CEQ 12 September 1975
Final statement to CEQ MAY 10 1977

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## SECTION 1

## PROJECT DESCRIPTION

Statement of Problem

1.01 The Red River is contaminated by natural salt sources in the upper part of the basin. The primary salt sources in the study basin are springs, seeps, and salt plains in the tributaries to the Red River above Lake Texoma. These sources emit common table salt, or sodium chloride, which has the chemical formula NaCl. The salt goes into solution in water and dissociates into sodium (Na+) and chloride (Cl) ions. Because of the high concentrations of these ions and other types that enter the streams as the water flows downstream, the water is unfit for most industrial, agricultural and municipal uses. Table 1-1 compares the chemical composition of sea water with some streams and lakes polluted by the chloride sources in the Red River Basin. In some of the source areas the salt concentrations are higher than in sea water. The sodium chloride contamination can be controlled because much of it originates from point sources; however, other contaminants such as sulfates cannot be controlled because they originate from non-point sources.

TABLE 1-1

COMPOSITION OF VARIOUS BRINES

| Expressed as | Sea Water | Spring #4 Area VIII | South Fork of Wichita River DS of Area VIII | Lake Kemp | Lake Wichita |
|---|---|---|---|---|---|
| Major Ions, Mg/l | | | | | |
| Chloride, Cl | 19,000 | 25,000 | 8,000 | 1,113 | 560 |
| Sulfate, $SO_4$ | 2,640 | 4,000 | 3,000 | 623 | 85 |
| Carbonate, $CO_3$ | 140 | 100 | 100 | ? | 60 |
| Sodium, Na+ | 10,500 | 16,000 | 5,000 | 732 | 265 |
| Calcium, Ca+ | 400 | 1,500 | 1,000 | 260 | 100 |
| Magnesium, Mg | 1,270 | 300 | 300 | ? | 30 |
| Potassium, K | 380 | 100 | 100 | ? | 10 |
| Others | 20 | 50± | 50± | ? | 50± |

Authorization and Purposes.

1.02 In 1957, the Public Health Service began studies to determine the causes of natural pollution in the Arkansas and Red River Basins. They concluded that chlorides and sulfates are the principal natural pollution.

1.03 In 1959, Congress authorized the Corps of Engineers to enter the study. The Public Health Service would identify the salt sources and the Corps would develop the plan to control the salt. Fifteen natural sources were identified.

1.04 In 1962, Congress authorized experimental projects at Estelline and Guthrie, Texas. The project at Guthrie was unsuccessful, but the Estelline Springs project was successful and is discussed in paragraph 1.25.

1.05 In 1966, Congress authorized Part I of the Arkansas-Red River Basin Water Quality Control Study on the Wichita River (Areas VII, VIII, and X), Red River Basin.

1.06 In 1968, preconstruction planning was initiated on the Wichita River and supplemental field investigations began.

1.07 In 1970, Congress authorized Part II of the Arkansas-Red River Basin Water Quality Control Study which included the remainder of the Red River Basin (Areas VI, IX, XIII, XIV, and XV) and Areas I thru IV in the Arkansas River Basin.

1.08 In 1972, preconstruction planning was essentially completed for the Wichita River Basin.

1.09 In 1973, preconstruction planning was initiated for the remainder of the Red River Basin and the Arkansas River Basin.

1.10 This report completes the Phase I Plan Formulation Studies for the remainder of the Red River Chloride Control Project.

Wichita River Basin

1.11 The proposed plan for Areas VII, VIII and X consists of construction of four low-flow dams for collection of brine-laden waters, two brine storage dams for holding the concentrated salt solutions during evaporation, and the necessary pumps and pipelines to transport the solutions from the low-flow lakes to the brine storage lakes. Approximately 4,400 acres are required for this plan, not including the acreage for Area VII disposal (Crowell Brine Dam), which is included in the Red River Basin figure discussed in paragraph 1.16. Crowell Brine Dam is used for storage in both basins. Locations of these facilities are shown on Plate 1-1.

Facilities required in each area are as follows:

Area VII

One low-flow dam
One brine dam (Crowell) in conjunction with Areas IX, XIII, and XIV
Pumps and pipelines as required

Area VIII

Two low-flow dams
One auxiliary low-flow dam (if required)
One brine dam (Truscott)
Pumps and pipelines as required

Area X

One low-flow dam
Pumps and pipelines to Area VIII brine dam (Truscott) as required

1.12 The Area VII low-flow dam is located at river mile 213 on the North Fork Wichita River and has a drainage area of about 492 square miles. The Area VII brine dam has a drainage area of about 46 square miles. Subsequent use of Area VII brine dam as an evaporation area for brines from Area IX, XIII, XIV, and XV will require expansion of the surface area from about 2,700 acres to about 5,980 acres. See paragraph 1.24 for a more detailed discussion.

1.13 The first stage Area VIII facilities consist of a low-flow dam, a brine storage dam, and the required pipelines and pumps. The first stage low-flow dam is located at river mile 74.9 on the South Fork Wichita River, has a drainage area of about 221 square miles, and creates a surface area of about 12 acres. The brine dam (Truscott) provides storage for both Areas VIII and X. It is located in the lower Bluff Creek Basin at river mile 3.6 on Bluff Creek, has a drainage area of about 26 square miles, and creates a lake surface area of about 2,980 acres. If needed to obtain adequate control, construction of a second stage low-flow dam at river mile 61.5 on the South Fork Wichita River will be considered. This auxiliary low-flow dam would have a drainage area of about 396 square miles and creates a surface area of about 4 acres.

1.14 The Area X facilities consist of a low-flow dam, the required pumps and pipelines, and will be constructed concurrently with the first stage facilities at the other two areas. The Area X low-flow dam is located at river mile 20.5 on the Middle Fork Wichita River, has a drainage area of about 60 square miles, and creates a surface area of about 6 acres. Brine storage is in Truscott Reservoir on Bluff Creek as explained in paragraph 1.13.

1.15 The ponds behind the low-water dams will vary with the local conditions, from maximum capacity to practically dry. The brine storage lakes will provide storage of brines for a project life of 100 years plus the 100-year storm event. The brine dams will be compacted earthfill structures with high level emergency cut spillways. The low-flow dams will be concrete slabs and aprons with deflatable dams. Flood waters will be allowed to pass downstream, but heavily concentrated brine solutions which occur during periods of low streamflow will be pumped to the brine storage lakes. Flood control would be insignificant. Recreation is not an authorized project purpose; however, inquiries have been made by interested citizens in surrounding communities about the possibility of including recreational facilities at the brine lakes and will be considered a few years in the future. The project does not conflict with other watershed conservation programs in the Wichita River watershed.

Red River Basin

1.16 The projects in the Red River Basin are Areas VI, IX, XIII, XIV, and XV. Approximately 16,260 acres are required to construct this plan. Area VI Brine Dam (Fish Creek) requires 3,500 acres of this total. Crowell Brine Dam requires 11,600 acres of this total and provides storage for disposal from Area VII of the Wichita River Basin. Locations of these facilities are shown on Plate 1-1.

Facilities required in each area are as follows:

Area VI

Three subsurface collection systems
One well point collection system
One low-flow dam
One brine dam (Fish Creek)
Pumps and pipelines as required

Area IX (Middle Pease River developed initially with future development of North Pease River)

Shallow well collection system
One brine dam (Crowell) in conjunction with Areas VII, XIII, and XIV
Pumps and pipelines as required

Area XIII and XIV

Existing subsurface collection system on Jonah Creek
Existing deep well injections
Shallow well collection system
One brine dam (Crowell) in conjunction with Areas VII and IX
Pumps and pipelines as required

Area XV (future development)

Three subsurface cutoff walls with shallow well collection
One brine dam (Crowell) in conjunction with Areas VII, IX, XIII, and XIV
Pumps and pipelines as required

1.17 The Area VI plan utilizes subsurface cutoff walls and collection conduits at the mouths of three canyons for collection of brine with attendant pumping facilities and pipeline for disposal in Fish Creek Brine Lake. Concrete subsurface walls, extending about 7 feet from the streambed to bedrock, would stop brine flows in the alluvium. Brine entering a perforated conduit at the upstream side of the cutoff wall would flow by gravity to a sump on one side of the stream. From the sump, the brine would be pumped to an evaporation lake located at river mile 1.6 on Fish Creek about five miles downstream. A low-flow dam and well point system would be located on the main stem of Elm Fork at river mile 54.0 to collect brine downstream from the canyons. The brine lake would have an emergency spillway for passing the probable maximum flood. The brine lake would completely store a 100-year flood on top of the 100-year accumulation of brine and sediment. This would amount to 133,500 acre-feet, of which 120,680 acre-feet would be for brine, 10,300 acre-feet would be for flood storage, and 2,520 acre-feet for sediment. The lake surface area would cover about 2,230 acres.

1.18 Brine from both North and Middle Pease Rivers, Area IX, would be collected by a shallow well collection system. However, collection on the North Pease is recommended for future development. The wells, spaced about 250 feet apart, would collect the brine at each principal salt emission area before the brine water flows to the surface or enters the alluvium. Each of the wells would be extended into the aquifer to the depth required for brine emission control. The brine collected would be pumped via pipeline to the Canal Creek Brine Lake. The pipeline was designed to include flows from Areas XIII and XIV plus flows from future development of Area XV and the North Pease River portion at Area IX; however, the pumps will have to be increased for the future development. The Canal Creek Brine Lake (Crowell Brine Lake) is discussed in Paragraph 1.24.

1.19 The collection facility utilized for Areas XIII and XIV would be the shallow well system. The wells, spaced about 250 feet apart, would collect the brine at each principal salt emission area before the brine water flows to the surface or enters the alluvium. The objective is to construct enough shallow wells in each area to collect the amount of brine flow necessary to achieve the desired level of control. Each of the wells would extend into the aquifer to the depth required for brine emission control (about 40 to 45 feet for Area XIII and 35 to 40 feet for Area XIV). Each will be encased with a PVC liner. A submergible pump designed for corrosion resistance would be placed within the casing. The wells would have a PVC discharge pipe connected to a common header pipe. The header pipe would connect to the transmission pipe to transport the brine to the disposal system. The existing Jonah Creek is utilized in the control for this area (see paragraph 1.27).

1.20 The brine from the shallow well system would be transferred to a sump where it would be pumped 30 miles to Area IX. This pipeline was designed to handle the future development at Area XV. As explained above, the final 18 miles of pipeline to Crowell Brine Lake is sized for future development.

1.21 The control facility for Area XV is recommended for future development. The collection facility utilized for Area XV would be a combination of the subsurface cutoff system and the shallow well system. Three separate collection areas would be utilized: Bluff Creek, Lost Mule Creek, and the main stem of Little Red River. The subsurface cutoff walls would be located at the mouths of Bluff and Lost Mule Creeks and upstream from the highway 70 bridge on Little Red River. The shallow well system would be located immediately upstream from the subsurface cutoff walls.

1.22 The wells for the shallow well system would be spaced about 250 feet apart and would collect the brine at the principal salt emission areas before the brine water flows to the surface or enters the alluvium. Each of the wells would extend into the aquifer to a depth required for brine emission control. The submersible pumps are designed for corrosion resistance and placed in a PVC lined casing. The wells would have a PVC discharge pipe connected to a common header pipe. The header pipe would connect to the transmission pipe to transport the brine to the disposal system. The subsurface cutoff wall would be placed downstream from the shallow well system to collect brine flows in the alluvium and would consist of subsurface cutoff walls in each of the source areas. The brine from each source area would be collected in a filter bed and transferred by a feeder line to a sump.

1.23 The collected brine from the three areas would be pumped to a common sump and pumped through a PVC-lined standard steel pipe 36 miles to Areas XIII and XIV. From here it would be pumped to Area IX and on to Crowell Brine Lake for disposal.

1.24 The Canal Creek Brine Lake (Crowell Brine Lake) located at river mile 1.6 on Canal Creek is a modification of the project reported in the Part I report for Area VII, in that brine storage would be included for Areas VII, IX, XIII, and XIV plus storage for future development at Area XV and the North Pease River portion at Area IX. Complete impoundment of a 100-year flood on top of 100 years accumulation of brine and sediment from the above source areas including future development requires a total of 353,200 acre-feet, of which 329,700 acre-feet is for brine, 17,700 acre-feet is for flood storage and 5,800 acre-feet is for sediment. The lake surface will encompass 5,980 acres for the initial pumping and would increase to 7,010 acres with future development. The brine dam has an emergency spillway for passing the probable maximum flood.

Experimental and Supplemental Projects Already in Operation

1.25 Experimental projects in the Red River Basin near Estelline and Guthrie, Texas, were authorized by the Flood Control Act approved 23 October 1962, Public Law 87-874, as recommended in Senate Document No. 105, 87th Congress, 2d Session. The experimental project was constructed in the spring of 1963 at Estelline Spring Area V to test the application of backhead as a means of suppressing individual brine springs. The experimental work was authorized on the basis of preliminary pumping tests made in 1961-1962 which provided data to calculate that the application of approximately 5 feet of hydrostatic head would stop the flow of the spring. The constructed test structure consists of a 9-foot-high circular earth dike, 340 feet in diameter, with an impervious core to firm rock around the spring, and contains a 4-foot-wide concrete outlet flume with stoplogs to control flow. In January 1964 the spring flow was completely suppressed with stoplogs inserted in the flume, and the spring has since maintained a relatively constant level. Hydrostatic pressure imposed on the spring by an average five feet of backhead appears to have contained the flow. Therefore, the structure is considered a permanent control installation and is now in operation as the existing chloride control project for Area V. The other project, also built in the spring of 1963, was at Area VIII on Spring No. 4, South Fork of the Wichita River. That project was operated for seven months. After that period of operation, it was concluded that application of hydrostatic backhead as a means of controlling the brine flow from brine springs in the area or areas with similar geologic conditions was not feasible because of brine seepage.

1.26 Supplemental field investigations in the Arkansas and Red River Basins were authorized by the Flood Control Act of 1966, Public Law 89-789, as recommended in Senate Document No. 110, 89th Congress, 2d Session. The areas to be investigated were Area I, on the Salt Fork of the Arkansas River, Oklahoma, and Area VI, Elm Fork, Red River, Harmon County, Oklahoma. Data on the Area I supplemental investigations will be presented in the Phase I General Design Memorandum for the Arkansas River Basin. Only limited published studies of subsurface geology in the vicinity of Area VI were available. A subsurface geological study was made to evaluate possibilities for successful subsurface injection of brine in Area VI. Conclusions drawn from the study were that Area VI did not possess necessary subsurface storage capacity at the site. However, excellent potential for subsurface storage exists south of Area VI. It was not considered practical to locate a test facility that far away from Area VI. Ample storage was indicated in the Ellenberger limestones and dolomites of Cambro-Ordovician age south of Area VI and at the site of Area XIII. For that reason, the supplemental investigation authorized for Area VI was moved to Area XIII.

1.27 The facilities at Jonah Creek consist of a collection and disposal system. The brine collection system includes both subsurface and surface collection, sumps, and holding tanks; whereas, the injection plant consists of a metal building housing filters, injection pump, and surveillance equipment. Power to the plant is supplied by a local electrical cooperative and fresh water is furnished by a rural water district. Related monitoring is accomplished by a weather station, water quality stations, and a seismic network installed near the facilities.

1.28 The subsurface collection consists of perforated pipe surrounded by crushed rock located at various depths in the alluvium. The surface water is collected in a box-shaped reinforced concrete structure placed upstream and adjacent to a low-flow detention dam. The brine from the collection systems flows to sumps and is then pumped to the injection plant. This plant consists of a 24-foot by 40-foot by 12-foot metal building which houses the filters, a 500 gpm injection pump, chemical feeders and surveillance equipment to shutdown the plant in case of any malfunction. The facility has been operational since 1974.

Fish and Wildlife Mitigation

1.29 The US Fish and Wildlife Service prepared a report, dated 4 May 1976, on the fish and wildlife resources in the basin. The mitigation plan as described therein appears reasonable and consistent with "Principles and Standards." To mitigate the loss of hunting opportunities and to insure maximum use of project lands for wildlife management purposes, it is recommended that project lands not required for operational purposes be made available to the Texas Parks and Wildlife Department, provided that that agency will assume the costs of operation and maintenance of the areas.

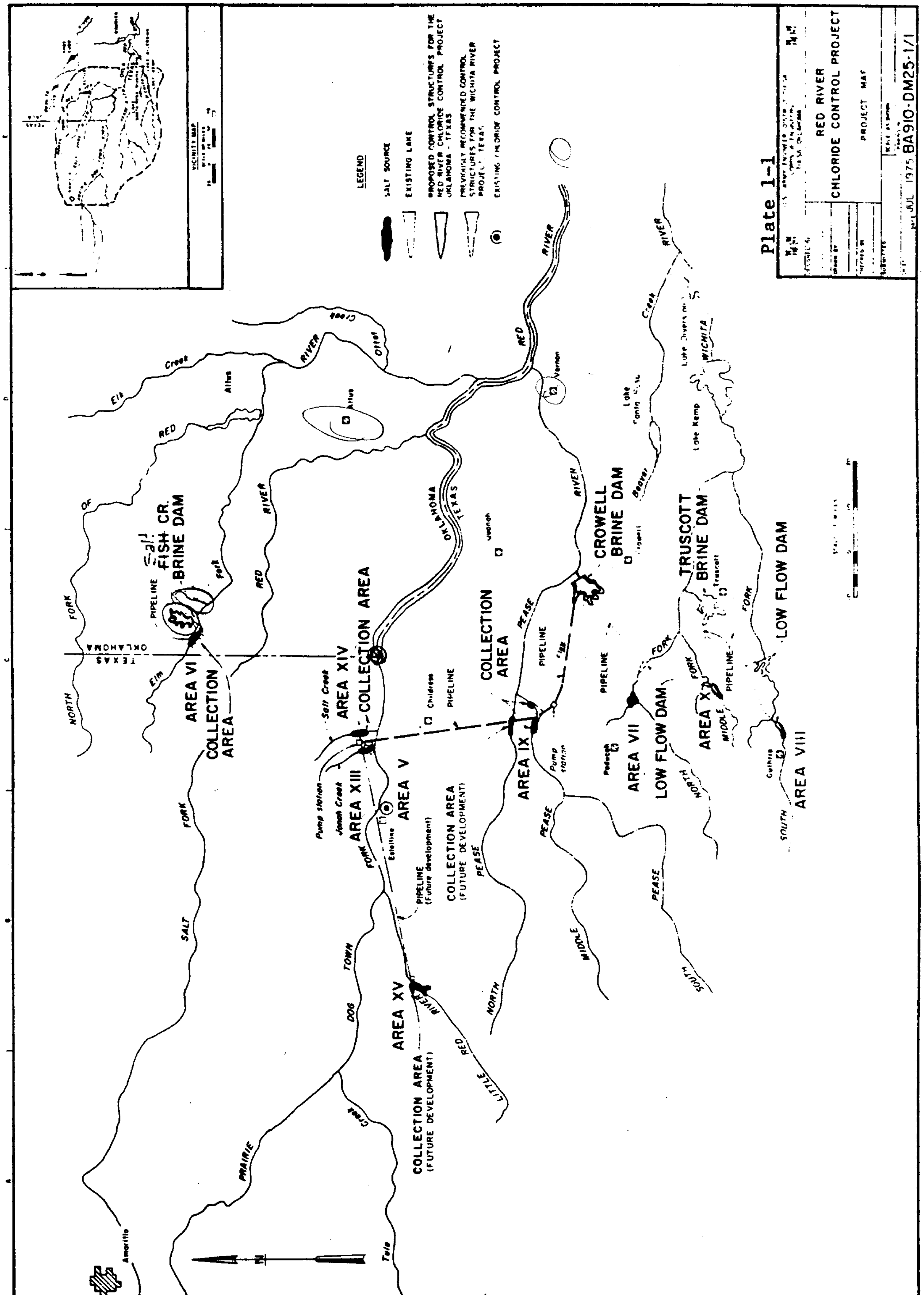
Plate 1-1
RED RIVER
CHLORIDE CONTROL PROJECT
PROJECT MAP
JUL 1975
BA910-DM25-1/1
VICINITY MAP
LEGEND
SALT SOURCE
EXISTING LAKE
PROPOSED CONTROL STRUCTURES FOR THE RED RIVER CHLORIDE CONTROL PROJECT OKLAHOMA - TEXAS
PREVIOUSLY RECOMMENDED CONTROL STRUCTURES FOR THE WICHITA RIVER PROJECT, TEXAS
EXISTING CHLORIDE CONTROL PROJECT
AREA VI
COLLECTION AREA
PIPELINE
Salt
FISH CR.
BRINE DAM
AREA XIV
COLLECTION AREA
Salt Creek
AREA XIII
AREA V
Pump station
Jonah Creek
Estelline
Childress
PIPELINE
PIPELINE (Future development)
COLLECTION AREA (FUTURE DEVELOPMENT)
AREA XV
COLLECTION AREA (FUTURE DEVELOPMENT)
AREA IX
COLLECTION AREA
Pump station
CROWELL
BRINE DAM
AREA VII
LOW FLOW DAM
Paducah
TRUSCOTT
BRINE DAM
Truscott
AREA X
LOW FLOW DAM
AREA VIII
Guthrie
Lake Kemp
Vernon
Altus
OKLAHOMA
TEXAS
NORTH FORK OF RED RIVER
SALT FORK
ELM FORK
Elk Creek
Otter Creek
RED RIVER
PRAIRIE DOG TOWN FORK
LITTLE RED RIVER
Tule Creek
NORTH PEASE
MIDDLE PEASE
PEASE
NORTH FORK
MIDDLE FORK
SOUTH FORK
WICHITA
Beaver Creek
Amarillo
N

## SECTION 2 - ENVIRONMENTAL SETTING WITHOUT THE PROJECT

2.01 Geographical Location and Basin Boundary. The Red River drains an area of approximately 93,450 square miles. The River has its headwaters in the high plains of northeastern New Mexico and the Texas Panhandle at an elevation of about 4,500 feet. It follows an easterly course forming the border of Oklahoma and Texas south of Hollis, Oklahoma, and then flows into the southwest corner of Arkansas southwest of Ashdown, Arkansas. From here the river turns and meanders in a southerly direction through Louisiana where it eventually discharges into the Atchafalaya River near Angola, Louisiana, at an elevation less than 100 feet.

2.02 Climatology. Situated between the warm waters of the Gulf of Mexico and the high plateaus and mountain ranges of the North American Continent, the Red River Basin has diverse meteorological and climatological conditions varying both temporally and spatially. Due to the proximity to the Gulf of Mexico, the eastern third of the basin is engulfed in a humid, subtropical climate with hot summers. The supply of Gulf moisture decreases westward and is frequently reduced during the colder months by invasions of drier, polar air from the north and west. As a result, most of the Red River Basin has a subtropical climate with dry winters and relatively humid summers. As the distance from the Gulf increases to the west, the summer moisture supply continues to decrease gradually. The most westerly region of the basin is semi-arid and rainfall is often inadequate for profitable agricultural production without supplemental irrigation. Humidities and cloudiness are generally greater and precipitation considerably heavier in the eastern section of the basin. Summers are long and occasionally extremely hot. Winters are short and generally not severe as periods of extreme cold are infrequent. The northwest experiences the harshest winters and the southeast the mildest.

2.03 Precipitation. The geographical distribution of rainfall in the Red River Basin decreases from the east to west. Precipitation in southern Louisiana annually averages more than 60 inches while in the western extremity the average annual rainfall is less than 16 inches. Patterns of seasonal precipitation vary considerably for different areas of the basin. As a result of squall-line thunderstorms, rains occur most frequently in late spring. Consequently, most areas of the basin show a peak rainfall amount in May. In the extreme western region of the basin, a singificant percentage of the total annual precipitation occurs during the summer months following the May peak. In this region, afternoon thunderstorms during July, August, and September account for most of the annual rainfall. Throughout the central part of the basin, July and August are relatively dry months. East of about 95 degrees west longitude, rainfall is fairly evenly distributed throughout the year. East of about 96 degrees west longitude, annual rainfall exceeds average potential evapotranspiration while west of this meridian, average potential evapotranspiration exceeds annual average rainfall. The eastern region of the basin averages less than two inches of snowfall while the extreme west portion averages about 20 inches annually.

2.04 Due to lower elevations and more frequent inflow of Gulf moisture, relative humidity averages about 90 percent higher in the eastern portion of the basin. Summer afternoon and early evening relative humidities are considerably lower than those in winter.

2.05 As is the case for most of the southern Great Plains, droughts of varying degree and duration are not uncommon to the western Red River Basin, although drought years have been far less frequent than years of dry summers and falls. The worst drought in recent years, by any classification, agriculture, economic, hydrologic or meterological, began in 1950 and persisted until 1957. Other notable drought periods in the Red River Basin were the dry years which occurred in the late 1890's, the drought of 1909 to 1919 and the very severe drought of the 1930's.

2.06 Temperature. The mean annual temperature of the Red River Basin averages 64F along the Oklahoma-Texas border. Mean maximum temperatures for January are 54 F along the Texas-Oklahoma border, 58 F through Arkansas, and 58 F to 68 F from northern to southern Louisiana. Temperatures of 32 F or less occur on an average of 55-65 days per year along the southern Oklahoma-Texas boundary and on fewer days for the south and east.

2.07 In the west, temperatures of 90 F or greater average about 120 days each year while in the east sections of the basin 90 F is reached 95-100 days a year. Temperatures of 100 F or higher are common over the basin from May well into September. In the western portion of the basin, the average number of 100 F days is 20-25 per year. Other sections of the basin will average somewhat fewer but very seldom will any location in the basin not reach a 100 F temperature sometime during the summer months.

2.08 Growing Period. The average length of the growing season, or freeze-free period ranges about 200 to 225 days along the Texas boundary of the Red River. The last spring freeze in this section occurs from March 27 to April 5 and the average date of the first fall freeze varies from November 5 to November 10 with the later dates occurring in the central basin area.

2.09 Freezing temperatures have occurred as late as April 20 and fall freezes have occurred as early as October 5. Frozen soil is not a major problem since its occurrence is rather infrequent, of very limited extent, and of brief duration. The average maximum depth that frost penetrates the soils is three inches throughout the basin. Extreme frost penetration reaches ten inches in the extreme western region of the basin.

2.10 Water Quality. The quality of water in the Red River Basin is degraded primarily by natural pollution sources in the Red River Basin above Lake Texoma. The principal natural pollutants are chlorides and sulfates. Major natural salt sources contribute about 4,100 tons/day and an additional 1,400 tons/day originate from man-made brines and minor natural sources. There are 10 major natural salt sources in the Red River

Basin. They occur as seeps, springs, and salt flats. Water quality becomes improved below Denison Dam because of inflow of high quality water from tributaries in southeastern Oklahoma and southwestern Arkansas.

2.11 Water quality samples are routinely collected from the Red River by the USGS. Table 2-1 provides data which are monthly averages during 1973 and 1974 for calcium, magnesium, sodium, sulfate, chloride, and specific conductance. It is obvious that the highest concentrations are in the upper approximately 150 miles and thereafter, the concentration gradient is low.

TABLE 2-1

PRESENT WATER QUALITY DATA FOR THE RED RIVER

| Station Name | Concentrations (mg/l) Ca | Mg | Na | $SO_4$ | Cl | Specific Conductance (micromhos at 25c) |
|---|---|---|---|---|---|---|
| Quanah, TX | 850 | 199 | 320 | 2261 | 6880 | 22,321 |
| Burkburnett, TX | 326 | 75 | 756 | 834 | 1918 | 7,213 |
| Terral, OK | 188 | 45 | 600 | 437 | 905 | 3,960 |
| Gainesville, TX | 160 | 39 | 205 | 338 | 802 | 3,240 |
| Denison Dam | 84 | 24 | - | 181 | 341 | 1,640 |
| Arthur City, TX | - | - | - | - | - | - |
| DeKalb, TX | 47 | 11 | - | 64 | 108 | 654 |
| Index, AR | - | - | - | - | - | - |
| Fulton, AR | - | - | - | - | 124 | - |
| Doddridge, AR | 37 | 9 | - | 50 | 122 | 612 |
| Hosston, LA | 40 | 10 | 47 | 46 | 74 | 506 |
| Shreveport, LA | - | - | - | - | - | - |
| Coushatta, LA | 31 | 7 | 39 | 35 | 62 | 416 |
| Boyce, LA | 36 | 9 | 38 | 37 | 61 | 426 |
| Moncla, LA | 31 | 7 | 27 | 32 | 52 | 385 |

2.12 Land Use. Land use within the area is devoted mainly to agriculture consisting of both farming and cattle ranching. About two-thirds of the acreage is used for livestock production and the remainder is devoted to farming. Most of the farming is dry land; irrigated lands make up about seven percent of the total acres in cultivation.

2.13 Water Supply. The region has no abundant underground supplies of water that would permit additional lands to be cultivated. Stream flows in the river are erratic and intermittent, fluctuating from zero to several thousand cfs under flood conditions. Groundwater supplies in the area are usually brackish and contain variable concentrations of natural chloride and sulfates. However, some of the deposits of recent alluvium

2.14 The Red River Above Denison Dam. The Red River above Denison Dam drains about 39,719 square miles. In general, the drainage is in a southeasterly direction. The streams and tributaries are not deeply entrenched, except for that part adjacent to the High Plains escarpment to the west. During extended droughts, only the major rivers maintain continuous flows.

2.15 Areas VII, VIII, and X in the Wichita River Basin, are located in Foard, Cottle, Knox, and King Counties, Texas. Areas VI, IX, XIII, XIV, and XV, in the Red River Basin, are located in Cottle, Childress, and Collingsworth Counties, Texas; and Beckham, Greer, and Harmon Counties, Oklahoma. All areas fall along the southwestern edge of the Osage Plains section of the Central Lowlands physiographic province, adjacent to the High Plains to the west.

2.16 Elevations in these areas range from 1,600 to 2,600 feet but the average elevation is about 1,900 feet. The average annual precipitation is about 15 inches and most of this falls as rain during the months of May through October. The average annual snowfall is but a few inches and does not contribute to runoff. The mean annual temperature is about 62 F and ranges from about 9 F to more than 100 F.

2.17 Areas VII, VIII, and X (Wichita River Basin). The Wichita River is a south bank tributary of Red River at about river mile 907. The long narrow basin drains a subhumid area of 3,485 square miles in north central Texas. The stream is formed by the North, Middle, and South Forks which originate in rolling hills and proceed easterly into the rolling prairie lands of north central Texas. These streams develop from small intermittent gullies in the upper reaches to well-defined streams with narrow, high bank, flood plains bordered by high bluffs in the lower reaches of the study areas. The drainage area above Lake Kemp Dam at river mile 126.7 is 2,100 square miles and that between Lake Kemp and Wichita Falls at the mouth of Holliday Creek is 1,240 square miles. Average annual rainfall ranges from 21 inches in the western part of the basin to 28 inches in the eastern. The average annual land pan evaporation is about 93 inches. The mean annual runoff from the basin above Lake Kemp is 185,400 acre-feet, equivalent to a flow of 256 cubic feet per second; however, there have been long periods of low flow and, at times, no flow.

2.18 The total drainage area of the Wichita River in the project area (Areas VII, VIII, and X) is more than 1,240 square miles. The principal streams are the North, Middle, and South Forks of the Wichita River. These three streams are perennial although periods of extreme low flow occur each year. The smaller tributaries are intermittent. The stream flow is extremely erratic and fluctuates from nearly zero to a recorded maximum of 13,000 c.f.s. for the South Fork under flood conditions. The area is the source of more than 450 tons per day of sodium chloride, equivalent to 65 percent of the total chloride load of the entire Wichita River Basin.

2.19 Area VII. Area VII is on the North Fork of the Wichita River. The The North Fork of the Wichita River at mile 213.0 has a drainage area of 492 square miles. The drainage basin is about 45 miles long and ranges from 7 to 20 miles in width. The weighted slope of the streambed above the damsite is about 17 feet per mile but near the damsite it is about 8 feet per mile. The average flow and chloride load for a 9-year period was computed to be 16.8 c.f.s. and 186.3 tons per day.

2.20 The brine collected in Area VII will be transferred out of the Wichita River Basin to a collection site in the Pease River Basin (see project map on page 1-3). Canal Creek, the proposed brine lake site (Crowell Brine Lake) is a south bank tributary to the Pease River. The drainage area above the proposed dam is about 46 square miles. The drainage basin is about 7 miles long and 9 miles wide with steep, rugged terrain in all but the lower one-fourth of the basin. The weighted slope at the damsite is about 20 feet per mile.

2.21 Area VIII. Area VIII is located on the South Fork of the Wichita River. The upper part of the basin is about 12 miles wide but diminishing to about 6 miles near the proposed pumping station. The average slope of the streambed near the proposed structure is about 13 feet per mile. The average flow and chloride load have been computed to be 16.5 c.f.s. and 170.1 tons per day. The Ross pumping station is a proposed secondary brine collection structure for Area VIII and is located at mile 61.5 on the South Fork of the Wichita River. The area of the drainage basin is about 396 square miles and extends about 38 miles west of the station. The width of the drainage basin ranges from about 11 to 14 miles. The average flow and chloride load for a 9-year period were calculated to be 29.3 c.f.s. and 195.2 tons per day.

2.22 Area X. The Lowrance pumping station is located on the Middle Fork of the Wichita River at mile 20.5 and is proposed for use as a brine collection structure for Area X. The drainage basin has an area of 60.4 square miles and begins about 9 miles north of Guthrie, 14 miles above the proposed structure. The basin is wedge-shaped in the upper reaches and widens to a width of 6 to 8 miles half-way to the proposed installation. The average flow and chloride load at this locality were calculated to be 8.6 c.f.s. and 48.1 tons per day.

2.23 The proposed Truscott Brine Lake will receive brine from Areas VIII and X. It is located on Bluff Creek, a south bank tributary of the North Fork of the Wichita River at mile 3.6. The drainage area of the basin is 26.2 square miles and it begins approximately 2 miles west and 1.5 miles south of Truscott. The drainage area extends about 6 miles northeastward to the proposed damsite and ranges in width from 7 miles at the upper end of the basin to about 3 miles at the damsite.

2.24 Area V - Estelline Spring. An experimental project was constructed in the spring of 1963 at Estelline Spring (Area V) to test the application of backhead as a means of suppressing individual springs. The suppressing structure is considered a permanent control installation and is now in operation as an existing chloride control project for Area V.

2.25 There are no sizeable natural lakes and no major reservoirs in the project area. There are, however, many farm tanks and ponds. Most of these are supplied from small springs fed from perched aquifers, from groundwater pumped by windmills from shallow aquifers, or from run-off from the small first-order streams. These ponds contain water of much lower salinity than that of the Wichita River and its tributaries.

2.26 Usable groundwater supplies are scarce because the underground waters are usually highly contaminated by natural chlorides and sulfates. For this reason, some of the inhabitants rely on cisterns to collect drinking water.

2.27 In areas VII, VIII, and X, Permian redbeds and associated evaporites of the Clear Fork and Pease River groups are the predominant surface rocks which include, in ascending order, the Choza Shale, San Angelo Formation, Flowerpot Shale, Blaine Formation, and the Dog Creek Shale. Total thickness of these formations is about 1,000 feet. From east to west the ascent in the stratigraphic column is accompanied by an increase in elevation. The Choza consists primarily of generally impervious shales with a few siltstone beds. The San Angelo is a fine grained relatively impervious sandstone or siltstone with occasional thin selenite or gypsiferous beds. The lower Flowerpot is mainly shale with thin selenite stringers,while the upper part becomes gypsiferous with several thin gypsum units separated by shales. The Blaine consists of two members, the Elm Fork with a relatively thick dolomite, gypsum , and shale sequence, and the Van Vacter Member with a shale, gypsum, and dolomite sequence. The Dog Creek is primarily shale with some gypsum and dolomite beds. Fossils are found infrequently in the formations. The gypsum and the dolomites, particularly of the Blaine Formation, are subject to solution, resulting in slump and collapse structures, and sinks and caves typical of karst topography. Replacement shales are commonly found occupying the standard gypsum position where extensive solutioning has taken place.

2.28 Regional tectonic features include parts of three major units. From south to north, they are the Red River uplift, the Palo Duro-Hardeman basin, and the Wichita-Amarillo uplift. The rocks generally dip slightly to the west although local structures occur in the form of folds and faults. Many of the local structural highs have been successfully developed by petroleum interests.

2.29 Overburden on the uplands is thin to nonexistent except where unconsolidated Pleistocene deposits occur locally. The thin residual soils are a product of the weathering of the parent rocks, generally shales and siltstones. The Pleistocene fluviatile deposits may be as much as 30 feet thick and consist of clays, silts, sands, and gravels. Windblown sands locally form dunes and dune ridges. Quaternary sediments, composed mainly of alluvial sands, gravels, and clays, occur along the river valleys. The thickness varies from a maximum of 30 feet on the South Wichita River to nothing along certain reaches of the Middle and North Wichita Rivers.

2.30 Local structures, stratigraphy, and topography control the occurrence of the salt springs and seeps in the upper reaches of the three rivers. Several formations probably contain halite in the subsurface which is removed through solution by groundwater movement. The springs on the North Wichita River emit from the Guthrie Dolomite of the Dog Creek Formation. The springs on the Middle Fork emit from gypsums and dolomites of the Elm Fork Member of the Blaine Formation. On the South Wichita the emission is from gypsums and dolomites of the Blaine Formation. Several artesian aquifers, generally dolomites of the Blaine or Dog Creek formations, contribute to the poor quality groundwater.

2.31 Areas VI, IX, XIII, XIV, and XV. Elm Fork of the North Fork of the Red River originates in the rolling hill country of the extreme eastern portion of the Texas Panhandle in Gray County. The stream follows a meandering easterly and southeasterly course through Wheeler and Collingsworth Counties, Texas, and Beckham and Greer Counties, Oklahoma, to its confluence with the North Fork of the Red River, approximately two miles below Lake Altus. In its headwaters in Texas, Elm Fork is essentially free of chloride contamination. As it approaches Oklahoma, the chloride content increases and reaches a load of approximately 510 tons per day at Carl, Oklahoma, below Area VI. Average annual runoff for the Elm Fork is 31,000 acre-feet with the chloride concentration above the Public Health Service standard (250 mg/l) more than 99 percent of the time.

2.32 The watershed of Elm Fork has a drainage area of approximately 416 square miles above the Area VI brine source. There are numerous small springs and seeps which come to the surface along the middle and lower reaches of the stream. Numerous seeps and springs emitting from Kiser, Robinson, and Salton gulches, together with seeps in Elm Fork, are the primary sources of chloride contamination. Total surface drainage area of these small streams is approximately 18 square miles with a discharge of 2.0 cubic feet per second (c.f.s.) and a contributing load of some 310 tons per day of chlorides to the Elm Fork total.

2.33 Area IX. Area IX is located on the North and Middle Pease Rivers in Cottle County, Texas. The Pease River, one of several tributaries to the Red River, encompasses approximately 2,100 square miles of drainage above Area IX. The North Pease River originates in the plains region of eastern Floyd County, Texas. A rapid drop (850 feet in 18.5 miles) characterizes the upper reaches. The stream merges with Quitaque Creek and flows eastward to its confluence with the Middle Pease River southeast of Childress, Texas. The stream is usually dry above the brine source area with rapid runoff whenever storms occur. Seeps in the salt area (major pollution begins about two miles east of US Highway 62 and extends eastward for approximately two miles) produce a flow of highly mineralized waters and maintain flows downstream at the Crowell gage except during dry periods. During these periods the brine evaporates or infiltrates into the streambed, leaving a salt encrustation. Runoff from storms flushes this accumulation downstream, carrying the majority of the load from this area. The total drainage area of the North Pease River is approximately 935 square miles. The long-term average chloride load from this area is about 320 tons per day.

2.34 The Middle Pease River has its origin approximately 14 miles west of Matador, Texas. Its runoff characteristics are similar to the North Pease except that it is a one-branch stream in the upper reaches. Numerous seeps enter the streambed, starting about 1 mile downstream from the US Highway 62-83 bridge 13 miles north of Paducah, Texas, and ending about 2 miles above the confluence of the North and Middle Pease River. This stream is also subject to large flushouts due to salt being deposited or stored near the surface. The total drainage area of the Middle Pease River (including the South Pease) is 1,165 square miles of which 65 are noncontributing.

2.35 Most of the salt water in Area IX appears at the surface as seeps rather than as springs. During normal flow periods there is no surface flow in the North Pease; however, at the confluence of the North and Middle Pease, flow is continuous. A highly variable load of chlorides is derived from this area because of the intermittent precipitation pattern and storage potential of the alluvium in the riverbeds. The average daily chloride load from this area is 340 tons.

2.36 Area IX is subject to hot, dry summers and moderately severe winters. The majority of the rainfall comes in the spring and fall months, generally in the form of locally intense thunderstorms. Surface evaporation rates vary from approximately 39 inches per year to 63 inches per year. The high evaporation rates combined with low amounts of precipitation make this region particularly conducive to brine disposal through evaporation ponds.

2.37 Areas XIII and XIV arelocated in the northwestern quarter of Childress County, Texas. These two areas contribute an average of 600 tons per day of chloride to the Red River load.

2.38 Area XIII. Area XIII is on Jonah Creek which enters Prairie Dog Town Fork of the Red River at river mile 1068, about seven miles west of US Highway 62-83 crossing north of Childress, Texas. Jonah Creek has a drainage area of about 63 square miles. Salt springs and seeps occur at numerous places along Jonah Creek throughout the source area with three major visible sources. One source, consisting of a number of small springs, is located near the confluence with Prairie Dog Town Fork of the Red River. Another source is in a box canyon located about one mile downstream from the ranch road crossing. Numerous small springs emerge from the canyon floor, which is composed of fractured dolomite. Much of the flow from the springs evaporates in the canyon and leaves a thick salt deposit. Other salt water springs and seeps occur in an outcrop of dolomite several hundred feet above the ranch road crossing. Seeps are in the sand alluvium and the springs flow from cracks and holes in the dolomite. At the present time as part of experimental work for the Jonah Creek salt area, a subsurface collection and deep well injection system are in operation. These facilities will be added to the recommended plan to help achieve the desired level of control at the Jonah Creek site.

2.39 Area XIV. Area XIV is located on Salt Creek in Childress County, Texas. The Salt Creek confluence with Prairie Dog Town Fork of the Red River is at river mile 1063, about two miles west of the US Highway 62-83 river bridge north of Childress, Texas. The source of salt pollution extends from the confluence upstream for about five miles. The major area of salt pollution is about one mile above the confluence and is attributed to seeps within the flow channel. A minor tributary, entering Salt Creek from the west and about one mile upstream from the county road bridge, also contributes salt water. The Salt Creek drainage area is about 152 square miles.

2.40 Both areas XIII and XIV are characterized by low annual rainfall, low humidity, hot summers, mild winters, considerable wind movement, and high evaporation losses. Average annual evaporation from surface waters is 54 inches.

2.41 Area XV. Area XV is located in the basin of the Little Red River, a tributary of the Prairie Dog Town Fork of the Red River. The stream originates in Hall and Briscoe Counties in Texas and joins the Prairie Dog Town Fork as a right bank tributary approximately 15 miles due west of Estelline, Texas. An average of 20 tons per day of chlorides is contributed by the Little Red River to downstream pollution from the primary area of salt contamination located in the north and south canyons which cross State Highway 70. Although the flow is intermittent, the small flows passing the highway are very high in chlorides and result in a substantial salt load. A salt plain at the mouth of Wildcat Creek (a tributary to the Little Red River) and a seep area in alluvium of the Little Red River contribute the remainder of the chlorides.

2.42 The region of area XV is characterized by moderate winters and long, dry summers. Most of the rain results from the passage of frontal systems and thunderstorms. Annual evaporation rates of surface waters were taken from records at Speer, Texas. Evaporation is in excess of 60 inches per year.

2.43 The rocks that crop out in areas VI, IX, XIII, XIV, and XV consist, for the most part, of marine sedimentary rocks of Permian age. These rocks are mostly red to gray gypsiferous shale and mudstone with interbedded sandstone, dolomite, and gypsum beds. Where present, the resistant sandstone, dolomite, and gypsum beds form mesas, buttes, and steep bluffs along valley walls. Remnants of Pleistocene terrace gravel of fluvial origin and lacustrine clay are found in several places in the project areas but nowhere are they thick or extensive. Some recent alluvium is found as a thin veneer along valley floors.

2.44 The Permian rocks consist of a sequence of "redbeds" (red-colored shale, mudstone, siltstone, and sandstone) and associated evaporites. They belong to the Flowerpot, Blaine, and Dog Creek formations of the Pease River Group and to the overlying Whitehorse Formation. Most units are sufficiently widespread to furnish stratigraphic correlation.

2.45 The Flowerpot Formation consists of a reddish-brown to maroon silty gypsiferous shale. The Blaine Formation is composed primarily of white massive gypsum beds and a thin dolomite interbedded with red silty gypsiferous shale. The Dog Creek formation consists of maroon, brown and red shales and contains several dolomite and associated gypsum units. The Dog Creek is in turn overlain by the Whitehorse formation which consists primarily of a fine grained sandstone and a number of thin gypsum beds. The distinctive part of the latter formation is that the matrix materials are, as commonly referred to, "an orange polished sandstone". The contact between the two formations is represented by the presence of the buff granular "Childress dolomite" that has an associated massive, white gypsum which locally attains a thickness of 4-10 feet. The total exposed thickness of Permian rocks directly related to the various projects is between 1000 and 1500 feet.

2.46 The Permian rocks are near-horizontal with a slight westward dip. Many of the beds are somewhat contorted, as a result of solution and collapse of gypsum.

2.47 Local stratigraphy and topography control the occurrences of the salt seeps and springs. Several formations contain halite in the subsurface which is removed through solution by groundwater movement.

2.48 Plants and Animals. The information in the following paragraphs concerning the distribution and abundance of plants and animals in the Red River Basin is taken from three reports which were done under contract to the Tulsa District. These reports contain an inventory of the plants and animals in the Red River Basin, whose range includes the areas that could be affected by the project. The studies for the area above Lake Texoma were done by West Texas State University at Canyon, and the study for the area below Lake Texoma was done by the University of Oklahoma, Norman. The complete reference for the reports is in Appendix B, Literature cited.

2.49 The Plants. The general area in which the Areas VII, VIII, and X are located is within the Rolling Plains biotic district described by Blair (1950). Within this biotic district, plant collections were made in Foard, Cottle, Knox, and King Counties. A checklist of the plants collected is presented in 2 reports by West Texas State University (see Literature cited). The rare and endangered species are listed in Table 2-2. Vegetation surveys were conducted at the proposed Crowell, Fish Creek, and Truscott Brine Lake areas.

2.50 Areas VI, IX, XIII, XIV, and XV are also located within the Rolling Plains biotic district described by Blair (1950). Within this biotic district, plant collections were made in Harmon County, Oklahoma, and in Briscoe, Hall, Childress, and Cottle Counties, Texas. Vegetation surveys were conducted at Areas VI, XIII, and XV by West Texas State University. The rare and endangered species of plants for these areas are listed in Table 2-3.

2.51 Many sites are no longer in the climax state. Because of prolonged grazing by domestic livestock, the consequent reduction or elimination of climax species, and the eventual invasion of different sites by the same invader species, many sites have lost the distinctness they possessed under climax conditions.

2.52 Crowell Brine Lake Area (Area IX). Four major vegetation types are found within the Crowell Brine Lake area. These are (a) Woodland, (b) Mixed Shrub Savannah, (c) Upland Grassland, and (d) Bottomland Grassland. In addition there are two minor vegetation types: Riparian and Marsh.

2.53 Woodland Vegetation Type. This vegetation type exists primarily on the escarpments bordering the level areas of the uplands and on step-like benches below steep ridges. It is underlain by soils classed in the Badland land type and in the Cottonwood-Vernon-Acme Complex. The woodlands are composed primarily of species of woody shrubs and bushes. The vegetation is dominated by junipers. Commonly associated with the junipers are sumacs, mesquite, pea-bush, and condalia. The latter three shrubs are more common on the drier slopes. There is a relatively sparse ground cover of mixed grasses and forbs interspersed among the woody species. There are enclaves of locally abundant grasses on some of the more nearly level benches. The common grass species are little bluestem, side-oats grama, hairy grama, and three-awn grasses. The areas occupied by this vegetation type have little agricultural value. The relatively small areas that support the locally abundant grasses provide some grazing value. The areas do provide suitable habitat for wildlife.

2.54 Mixed Shrub Savannah Vegetation Type. This vegetation type occurs on gently sloping areas that are underlain by soils of the Vernon-Badland Complex. These areas are usually adjacent to the steeper areas of the Woodland Vegetation Type. Disturbance by heavy grazing has apparently caused an increase in the number of shrubs, converting the climax grassland into a savannah disclimax. The shrub aspect includes junipers, mesquite, squawbush sumac, condalia, and algerita. These shrubs are more widely spaced than those of the adjacent Woodland Vegetation Type, and there is a greater proportion of the more xeric types such as mesquite and condalia. Also, those grasses such as blue grama and side-oats grama, that decrease in cover with increased grazing pressure have been largely replaced by those grasses that increase under such conditions: three-awns, trichens, tobosa, and buffalo grass. In addition, awns that have been severely overgrazed have been invaded by cacti, yucca, and various species of annual forbs.

TABLE 2-2

RARE AND ENDANGERED SPECIES IN AREAS VII, VIII, AND X

Rare Species[2]

Grasses

*Andropogon gerardi* Vitman
[1]*Andropogon scoparius* var. *Neomexicanus* (Nash) Hitchc.
[1]*Elymus canadensis* L.
*Eragrostis trichodes* (Nutt.) Wood
*Sorgastrum nutans* (L.) Nash
[1]*Stipa comata* trin. & Rupr.

Forbs

[1]*Englemannia pinnatifida* Gray
[1]*Eustoma grandiflorum* (Raf.) Shinners
[1]*Calylophus serrulatus* (Nutt.) Raven

Woody Plants

[1]*Atriplex confertifolia* (Torr. & Frem.) Wats.
[1]*Echinocactus texensis* Hopffer
*Cercocarpus montanus* Raf.
[1]*Lycium berlandieri* Dun var. *parviflorum* (Gray) Terrac.
[1]*Bumelia lanuginosa* (Michx.) Pers. var. *oblongifolia* (Nutt.)

Endangered Species[2]

Forbs

[1]*Eriogonum correllii* Reveal

Woody Plants

*Morus microphylla* Buckl.

[1]Those species that are either rare or endangered which will be covered with brine in the two lakes.

[2]Most of the rare or endangered species of plants listed in this report are documented by the Rare Plant Study Center of the University of Texas at Austin, and the Agricultural Research Service of the United States Department of Agriculture. The terms rare and endangered are defined also by the Rare Plant Study Center and are used in this report in the same context.

TABLE 2-2 (CONT)

Rare A rare species or subspecies is one that, although not presently threatened with extinction, is in such small numbers throughout its range that it may be endangered if its environment worsens. Close watch of its status is necessary.

Endangered An endangered species or subspecies is one whose prospects of survival and reproduction are in immediate jeopardy. Its peril may result from one of many causes -- loss of habitat, change in habitat, overexploitation, predation, competition or disease. An endangered species must have help, or extinction will probably follow.

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2.55 Upland Grassland Vegetation Type. This grassland vegetation type occupies the nearly level areas that are underlain by soils of the upland Tillman series. Under climax conditions, these areas seem to be capable of supporting such grasses as blue grama, sideoats grama, vine-mesquite, Arizona cottontop, and western wheatgrass. Apparently because of overgrazing, these grasses decreased in cover and were largely replaced by tobosa grass and buffalo grass. The shrubs (mesquite and condalia), cacti, and annual forbs that are common on some sites also seem to be the result of severe grazing pressure. These sites occur primarily along the edges of this vegetation type, where it abuts against the Woodland and Mixed Shrub Savannah Vegetation Types. The present aspect, then, is one of a broad expanse of grassland dominated by tobosa and buffalo grasses, interrupted along its edges by interdigitations of severely overgrazed sites.

2.56 Bottomland Grassland Vegetation Type. This vegetation type is found on the nearly level areas of the bottomlands that are underlain by alluvial soils. Under climax conditions, this type would seem to be suited to dominance by such tall and mid grasses as sand bluestem. Indian grass, switchgrass, little bluestem, side-oats grama, and Canada wildrye. Occasional trees and shrubs, such as junipers and mesquite, can be expected to occur in such a climax grassland. The main influence of grazing has seemed to be a change in the species composition of the grasses. Buffalo grass, three-awns, sand dropseed, western wheatgrass, hairy grama, and tobosa grass have increased in cover at the expense of the climax grasses.

2.57 Minor Vegetation Types. There are two minor vegetation types within the confines of the proposed Crowell Brine Lake. A riparian community occurs at certain areas along Cedar and Canal Creeks. A marsh community occurs around the larger stock ponds. The riparian community occurs along the major creeks of the area and is best developed in mesic, narrow valleys, These mesic sites support a dense growth of mesquite, soapberry, and salt cedars, with occasional junipers intermixed among the more common woody plants. The sloping banks are often clothed with tall grasses, such as switchgrass and Canada wildrye. What is here called the marsh community actually consists typically of two zones of vegetation around the larger stock ponds. The two zones encountered in approaching the ponds from the surrounding areas are a zone of tobosa grass and alkali sacaton and a reed swamp dominated by reed grass, with a considerable number of salt cedars.

TABLE 2-3

RARE AND ENDANGERED SPECIES IN THE AREAS VI, IX, XIII, XIV, AND XV

Rare Species[2]

Grasses

Andropogon gerardi Vitman
[1]Andropogon scoparius var. neomexicanus (Nash) Hitchc.
[1]Elymus canadensis L.
[1]Eragrostis trichodes (Nutt.) Wood
[1]Sorgastrum nutans (L.) Nash
[1]Poa arachnifera Torr.
[1]Phlaris canariensis L.
[1]Stipa commata Trin. & Rupr.
Tripsacum dactyloides L.

Forbs

Arenaria stricta Michx. var. texana Robins
Aster fendleri Gray
[1]Castilleja purpurea (Nutt.) G. Don var. citrina (Penn.) Shinners
[1]Engelmannia pinnatifida Torr. & Gray
[1]Eustoma grandiflora (Raf.) Shinners
[1]Calylophus serrulatus (Nutt.) Raven
[1]Psoralea hypogaea Torr. & Gray
[1]Pilostyles thurberi Gray
Teucrium canadense L.

Woody Plants

[1]Atriplex confertifolia (Torr. & Frem.) Wats.
[1]Cercocarpus montanus Raf.
Bumelia lanuginosa (Michx.) Pers. var. oblongifolia (Nutt.) Clark
Pluchea purpurascens (Sw.) DC.

Endangered Species[2]

Forbs

Eriogonum correllii Reveal

Woody Plants

[1]Morus microphylla Buckl.

TABLE 2-3 (CONT)

Endangered Species[2]

[1]Those species that are either rare or endangered which could be affected by the project.

[2]Most of the rare or endangered species of plants listed in this report are documented by the Rare Plant Study Center of the University of Texas at Austin, and the Agricultural Research Service of the United States Department of Agriculture. The terms rare and endangered are defined also by the Rare Plant Study Center and are used in this report in the same context.

Rare. A rare species or subspecies is one that, although not presently threatened with extinction, is in such small numbers throughout its range that it may be endangered if its environment worsens. Close watch of its status is necessary.

Endangered. An endangered species or subspecies is one whose prospects of survival and reproduction are in immediate jeopardy. Its peril may result from one or many causes--loss of habitat, change of habitat, over-exploitation, predation, competition, or disease. An endangered species must have help, or extinction will probably follow.

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2.58 Fish Creek Brine Lake (Area VI). There are five major range sites occurring in the general area of the proposed brine lake at Area VI: (1) Mixed Redlands, (2) Rough Breaks, (3) Loamy Bottomland, (4) Loamy Prairie, and (5) Hardland.

2.59 Mixed Redlands Range Site. This vegetation type occurs on the rolling upland areas. These areas are dissected by numerous drainage ways and are underlain by soils of the Vernon gypsum outcrop complex. These soils are loamy and clayey in texture and absorb water slowly. This vegetation type is suited to dominance by mid-grasses. The major components of climax stands are little bluestem, side-oats grama, sand bluestem, and blue grama. Blue grama and buffalo grass assume dominance on gently sloping areas. Disturbance by grazing has resulted in a vegetation type somewhat removed from climax. Many stands are now characterized by those grasses that increase in abundance under grazing pressure, such as buffalo grass, sand dropseed, silver bluestem, and purple three-awn. While woody plants should be essentially absent from climax stands, excessive and prolonged overgrazing has allowed mesquite to invade and assume dominance in certain stands.

2.60 Rough Breaks Range Site. This vegetation type occurs on the more steeply sloping escarpments. These areas are often subject to severe run-off and erosion. The underlying soils are classed as Rough Broken Land. Because of habitat heterogeneity, these stands have a high species diversity. Climax stands could be expected to contain such grass species as sand bluestem, little bluestem, switchgrass, Indian grass, Canada wildrye, and tall dropseed ; forbs such as blue sage, compass weed, ruellia, narrowleaf bluets, and sundrop. Grazing has resulted in the increase at some sites of such grass species as side-oats grama, blue grama, hairy grama, purple three-awn and rough tridens; forbs such as dotted gayfeather, greenthread, wild alfalfa, and wild blue indigo; and shrubs such as skunkbush. Excessive grazing of some areas has resulted in the invasion by grass species such as Japanese brome, little barley, fescue grass, silver bluestem, buffalo grass, hairy tridens, sand dropseed, and red three-awn; forbs such as annual sunflower, croton, annual wild buckwheat, Baldwin ironweed, snakeweed, and mesquite.

2.61 Loamy Bottomland Range Site. The loamy bottomland range site is found primarily along Fish Creek. These nearly level areas are underlain by deep, loamy soils and are subject to overflow and siltation during periods of heavy rainfall. Climax vegetation is dominated by tall grasses. Important constituents of climax stands are sand bluestem, big bluestem, Indian grass, switch grass, Canada wildrye, Virginia wildrye, purpletop, leadplant, blue sage, kuhnia, Maximilian sunflower, wholeleaf rosinweed, Virginia creeper, and poison ivy. Species that are minor components of the climax vegetation but that increase under grazing pressure include tall dropseed, western wheatgrass, vine-mesquite, blue grama, side-oats grama, buffalo grass scribners panicum, American elm, hackberry, and buttonbush. Species that invade as these areas deteriorate are fescue grass, Japanese brome, silver bluestem, sand dropseed, red three-awn, tumble windmill grass, gummy lovegrass, deervetch, annual sunflower, basketflower, giant ragweed, western ragweed, and Baldwin ironweed. These invader species are relatively common on much of the area along Fish Creek.

2.62 Loamy Prairie Range Site. The loamy prairie range sites occur on the gently sloping to nearly level uplands. These sites do not occur within the confines of the proposed brine lake, but are common on areas adjacent to its boundaries. Shallow, loamy soils of the Cottonwood-Acme complex are characteristic of these sites. Component species of climax stands are sand bluestem, little bluestem, switchgrass, Indian grass, Canada wildrye, tall dropseed, western wheatgrass, lead plant, catclaw sensitive briar, crameria, ground plum, englemann daisy, kuhnia, blue sage, poppymallow, and spiderwort. Under moderate grazing pressure a number of minor components of the climax vegetation come into prominence: side-oats grama, blue grama, wild alfalfa, wild blue indigo, dotted gayfeather, prairie coneflower, and antelope horn. Under excessive and prolonged grazing a number of species invade these range sites: silver bluestem, sand dropseed, three-awn, tumble windmill grass, Baldwin ironweed, silverleaf nightshade, Carolina horsenettle, curly-cup gumweed, yarrow, western ragweed, mesquite, sumac, and skunkbush.

2.63 Hardland Range Site. The hardland range site does not occur within the confines of the proposed brine lake. There are widely scattered stands of this site found near the proposed boundaries of the lake. The common soils are the deep, clayey, slowly permeable soils of the Quanah-Talpa complex. The main species that make up climax stands are sand bluestem, side-oats grama, vine mesquite, western wheatgrass, Canada wildrye, wild alfalfa, ruellia, and sundrop. Those species that increase under moderate grazing pressure include blue grama, buffalo grass, sand dropseed, silver bluestem, purple three-awn, white tridens, and tumble windmill grass.

Deteriorated sites are characterized by little barley, Japanese brome, prairie cupgrass, Texas grama, red three-awn, croton, annual sunflower, buffalo bur, red-seeded plantain, annual broomweed, Carolina horsenettle, silver nightshade, curlycup gumweed, snow-on-the-mountain, western ragweed, prickly pear, and mesquite.

2.64 Truscott Brine Lake Area (Area X). Four vegetation types or plant communities can be recognized in the Truscott Brine Lake area. These are (a) Juniper Scrub, (b) Mesquite-Grassland Savannah, (c) Mesquite Thicket, and (d) Riparian.

2.65 Juniper Scrub Vegetation Type. This vegetation type occurs on the less strongly sloping areas below the more steeply sloping escarpment that borders the Truscott Brine Lake site on all sides. The vegetation is underlain primarily by Permian red-bed materials in which there has been very little soil development.

2.66 This plant community is generally very low in plant species diversity and can be considered as a depauperate phase of the Woodland Vegetation Type of the Crowell Brine Lake site. Junipers are by far the most common woody plants, and in some small areas are the only perennial plants. Lesser numbers of other shrubs, such as mesquite and condalia, occur intermixed among the junipers. Erosion occurs so rapidly that it prevents the development of much soil and consequently of much of a ground cover of perennial species. On a few areas enough soil has accumulated for a sparse ground cover to develop. Tobosa grass and side-oats grama are the most common components of this stratum. There is little agricultural value afforded by these areas, but they do provide habitat for wildlife.

2.67 Mesquite-Grassland Savannah Vegetation Type. This vegetation type occurs on the more nearly level areas, adjacent to the Juniper Scrub Vegetation Type of the more sloping lands above. The alluvial soils are formed in loamy sediments derived from the red beds. It seems likely this type was originally a shrub-grass subclimax that was prevented from reaching a grassland climax by the shallow water table. There has been extensive disturbance by domestic livestock that has further increased the relative numbers of woody plants. The great number of shrubs is not entirely due to disturbance, but disturbance has increased the numbers over those of the original subclimax community. The dominant shrub is mesquite, but there are a number of condalias. Occasional individuals of salt cedar, soapberry, and hackberry add to the diversity of the woody overstory. Common components of the herbaceous understory are buffalo grass, tobosa grass, sideoats grama, three-awns, and numerous species of forbs. The savannah varies a great deal within this site. Locally there are relatively large areas of tall grass that are dotted only here and there with shrubs. Elsewhere, the shrubs are quite numerous and consequently the grass cover is reduced.

2.68 Mesquite-Thicket Vegetation Type. The bottomlands of the site support a Mesquite-Thicket Vegetation Type. Like the surrounding Mesquite-Grassland Savannah, this type is underlain by alluvial soils. Like the Mesquite-Grassland Savannah, it seems likely that this site supported trees and shrubs even before it was disturbed by domestic livestock. Today the trees and shrubs occur in such numbers that the site is best described as a thicket. Although mesquite is the dominant woody species, there are also some salt cedars and soapberry plants. Despite the great number of trees and shrubs, there is a dense cover of bermuda grass, buffalo grass, tobosa grass, alkali sacaton, and of various species of forbs such as cocklebur.

2.69 Riparian Vegetation Type. This vegetation type occurs along the banks of the creeks that run through the area. It extends as a narrow band of vegetation parallel to the creek channels. Most of the trees and shrubs of the other vegetation types occur as components of the riparian community, but salt cedars seem to assume dominance. Willow, wolfberry, soapberry, hackberry, and mesquite complete the common woody plant aspect. Cocklebur and ragweed are the most conspicuous forbs.

2.70 Area XIII. There are five major range sites in the general area of the proposed brine lake at Area XIII. These are (1) Mixed Land Range Site, (2) Bottomland Range Site, (3) Hardland Range Site, (4) Rough Breaks Range Site, and (5) Very Shallow Range Site.

2.71 Mixed Land Range Site. Because of soil heterogeneity, varying degrees of disturbance, varying types of topography, and proximity to drainage ways, the Mixed Land Range Site consists of a number of relatively small but diverse plant communities. Stands of this site typically occur on gently sloping to rather steep uplands and are underlain by mostly deep soils that absorb water readily. The main soils are Quinlan-Woodward loams, Woodward loam, and Carey loam. The climax Mixed Land Range Site is characterized by short-to mid-grasses, such as blue grama, side-oats grama, Arizona cottontop, and plains bristlegrass. Western wheatgrass, vine mesquite, and switchgrass are common in drainages. Grass species that increase in relative importance in the communities that are moderately grazed are hairy grama, buffalo grass, Texas bluegrass, silver bluestem, and three-awn. Species that invade deteriorated areas are hairy tridens, Texas grama, sand muhly, tumble grass, tumble windmill grass, gummy lovegrass, hooded windmill grass, red grama, prickly pear, lotebush, tosajillo, mesquite, white sage, and numerous annual forbs.

2.72 Bottomland Range Site. This range site occurs on the gently sloping to flat areas adjacent to Dry Salt Creek and some of the larger drainages into the Dry Salt. The soils are primarily sands, but some loam soils occur. Sites that have been stabilized for long enough periods to support climax vegetation are composed of Indian grass, switchgrass, sand bluestem, little bluestem, side-oats grama, Canada wildrye, and occasional cottonwood, hackberry, and elm. Increaser species include vine mesquite, Texas bluegrass, western wheatgrass, buffalo grass, blue grama, white tridens, silver bluestem, and Texas winter grass. Invader species include sand dropseed, three-awn, western ragweed, prickly pear, and mesquite.

2.73 Hardland Range Site. The Hardland Range Site occurs on nearly level to gently-sloping topography. The main soils are Abilene clay loam and St. Paul silt loam. Because of a clayey, slowly permeable subsoil, these soils are somewhat droughty and produce short- to mid-grasses. Most of these soils are or have been in crop production. The dominant species of climax vegetation are blue grama and side-oats grama. Vine mesquite and western wheatgrass occur primarily in depressions. As the range is grazed buffalo grass, tobosa grass, Texas wintergrass, silver bluestem, and white tridens increase. Badly deteriorated ranges are invaded by three-awn, hairy tridens, sand dropseed, Texas grama, tumblegrass, prickly pear, and mesquite.

2.74 Rough Breaks Range Site. The Rough Breaks Range Site occurs only on the more steeply-sloping areas. The substrate is primarily weakly consolidated siltstone and very fine-grained sandstone. Because of their steepness, these areas are subject to considerable erosion. A good condition range site is characterized by side-oats grama, blue grama, and little bluestem. Sand bluestem, Indian grass, switch grass, vine mesquite, and Canada wildrye occur in draws. Hairy grama, black grama, silver bluestem, buffalo grass, three-awn, white tridens, and sand dropseed are characteristic of ranges in poorer condition. Mesquite, prickly pear, and lotebush are common on deteriorated sites.

2.75 Very Shallow Range Site. This site occurs on knolls and is underlain by Latom stony loam soil. The soil is shallow and has low water holding capacity and fertility. The climax vegetation is dominated by short- and mid-grasses, such as blue grama, side-oats grama, and little bluestem. Increasers include buffalo grass, hairy grama, silver bluestem, slim tridens, and black grama. There are a number of invaders, such as sand dropseed, Texas grama, sand muhly, mesquite, lotebush, and yucca.

2.76 Area XV. Six range sites were recognized at Area XV: (1) Mixed Land, (2) Rough Breaks, (3) Modified Loamy Bottomland, (4) Sandy Bottomland, (5) Modified Mixed land, and (6) Loamy Bottomland.

2.77 Mixed Land Range Site. The Mixed Land Range Site occurs on the gently-sloping to steep uplands. These areas are characterized by Woodward-Quinlan loam soils that are very shallow to moderately deep, depending on the steepness of slope. Erosion has cut deeply into the silty and sandy Permian redbed formation, severely dissecting the areas. Climax stands of this range site are characterized by side-oats grama, blue grama, Arizona cottontop, plains bristle-grass, western wheatgrass, and vine mesquite. Alkali sacaton occurs on saline areas. Moderate grazing results in the relative increase of buffalo grass, hairy grama, tall dropseed, and silver bluestem. Excessive and prolonged grazing results in the invasion of Texas grama, sand muhly, red grama, hairy tridens, mesquite, lotebush, tasajillo, prickly pear, and juniper.

2.78 Rough Breaks Range Site. This range site occurs on steep, severely gullied areas and escarpments. The substrate consists mainly of sandy and silty Permian red-bed materials. Vegetation may be sparse on steep escarpments, but there may be a diverse array of species on the less steep areas. Dominant components of climax vegetation are side-oats grama, blue grama, and little bluestem. Those species which are normally minor components of the climax stand but which increase with increased grazing pressure are hairy grama, black grama, buffalo grass, and silver bluestem. On severely disturbed sites there are a number of invader species, such as Texas grama, hairy tridens, mesquite, juniper, and prickly pear.

2.79 Modified Loamy Bottomland Range Site. This range site is found on the nearly level to gently sloping areas adjacent to the Little Red River and Oxbow Creek. The dominant grass species expected in climax vegetation are Indian grass, switch grass, little bluestem, Canada wildrye, sand bluestem, and side-oats grama. Alkali sacaton is common on saline soils. Vine mesquite, Texas wintergrass, white tridens, and western wheatgrass commonly increase under moderate grazing pressure. The invaders include buffalo grass, three-awn, western ragweed, mesquite, prickly pear, and annual weeds.

2.80 Sandy Bottomland Range Site. This range site occurs on nearly level areas, primarily along the Little Red River. The soils are sandy and saline. Floodwaters frequently deposit material on this site, greatly changing the vegetative cover. The Sandy Bottomland Range Site supports many types of vegetation. Nonsaline areas support a stand of tall grasses. Many of the soils along the Little Red River are quite saline and support a number of saline-tolerant plants, including a number of succulents.

2.81 Modified Mixed Land Range Site. According to standard range-site nomenclature, this site should be named Mixed Land Range Site. However, this site has been segregated from the Mixed Land Site because of its unusual character. The site is found only along drainageways leading into the Little Red River and Oxbow Creek. All stands support a dense growth of trees and shrubs.

2.82 Loamy Bottomland Range Site. The climax dominants, increaser species, and invader species are those described for the Modified Loamy Bottomland Range Site. These stands are subject to frequent flooding, so climax stands do not have enough time to develop.

The Animals.

2.83 Fish. Streams in Areas VI, IX, XIII, XIV, and XV support limited populations of fish. Dry Salt Creek (Area XIII, XIV) and Fish Creek (Area VI) have a number of "potholes" containing small populations of sunfish and bullhead catfish. The lower salinities of Dry Salt Creek and Fish Creek support a more diversified fish fauna than do most streams in the area.

2.84 The sport fishery of the streams in Areas VII, VIII, and X (Wichita River Basin) is also limited. The middle fork of the Wichita River supports a population of sport and food fishes, but the river basin lies within the boundaries of a few large ranches and the owners do not allow the public access to the stream. The north and south forks of the river do not support a fishery to any large extent because of poor habitat (heavy salt loads and low stream flows). Some sport fishing is available upstream from the major salt pollution areas during and immediately after high stream flows when fish move upstream from Lake Kemp. Species occurring in these upstream reaches include largemouth bass, channel catfish, and green sunfish.

2.85 Canal Creek (Area IX) near Crowell, Texas, forms the basin for the proposed Crowell Brine Lake. This stream has some large "potholes" in it, which contain populations of sunfish and bullhead catfish. Public access to this stream is denied by owners of the ranches in which the stream basin lies. The other streams with which the project is associated do not have permanent water supplies, and so do not support fish populations.

2.86 In contrast to the situation for sport fishes, conditions are quite favorable for the survival of several species of minnows. The distribution and abundance of several species are closely associated with the different salinity conditions that occur throughout the area of influence. The Red River pupfish and plains killifish are most abundant in the shallow, highly saline streams. Areas of moderate salinity seem to favor the plains minnow, speckled chub, Red River shiner, and the emerald shiner. In the deeper less saline areas, the red shiner, mosquitofish, fathead minnow, and bullhead minnow are more abundant.

2.87 A substantial commercial bait minnow fishery exists for some species. The Red River shiner, red shiner, and plains minnow are the most valuable and sought after species. These species are most abundant in the lower Elm Fork River (Area VI) and the upper Red River. A commercial potential exists in the lower Pease River (Area IX) and lower Prairie Dog Town Fork (Areas XIII, XIV) but county laws restrict harvest to the point of limiting commercial operations.

2.88 None of the fishes which inhabit the streams of the study area are rare or endangered. However, one species, the Red River pupfish, is endemic to the Western reaches of the Red and Brazos Rivers. The Red River pupfish, Cyprinodon rubrofluviatilis, is unique in that it is one of ten species of pupfishes in the United States that is restricted to inland waters. Of these ten species, seven are either on the National Endangered Species lists or on the Texas Organization for Endangered Species (TOES) list. All seven species of pupfish have been endangered because of man's activity. In the study area, the Red River pupfish occurs commonly in both the North and South Forks of the Wichita River and is uncommon or absent from the Middle Fork, except near the junction of the North Fork. The entire range of this fish is in the Red and Brazos Rivers in western Oklahoma and Texas. The western limit is the High Plains Escarpment and the eastern limit is Oscar Creek in Jefferson County, Oklahoma (Echelle, et. al. 1972).

2.89 Established populations are found only in the more saline tributaries of these rivers. Small numbers of pupfish are infrequently found in low salinity areas; however, these are usually close to areas of high salinity where established populations increase the chances that the pupfish wanders into the low salinity areas. The Red River pupfish is active at temperatures between 4 C and 39 C and reproductive between 12.8 C and 33.9 C. They are extremely tolerant of a range of salinities. Some populations exist in salinities of over 50 ppt.(parts per thousand), and are physiologically able to survive "sweet" water (under 10 ppt.).

2.90 Although the Red River pupfish appears to be tolerant to many of the usual intrinsic factors limiting fish dispersal, there are apparently some extrinsic factors determining their realized niche. Echelle et. al. (1972a) believe that both predation and competition with many more specialized species are limiting factors in the success and survival of the pupfish in low salinity waters.

2.91 Amphibians. The number of species reported from the area above Lake Texoma is limited because of the lack of habitat. In all, 15 species are known to occur in this area, with 14 species being common. The only species that is considered to be rare in the area is Couch's spadefoot toad, which is an inhabitant of the shortgrass prairie and stream breaks. Its' range extends just barely into the southern edge of Oklahoma. This species is fairly common in other parts of the southwestern United States. The leopard frog and bullfrog are common in streams of low salinity. In some reaches, larvae of the barred tiger salamander are collected in large numbers from ponds and playa lakes and exported to other states as fish bait. Several species of toads are common in the prairies and cultivated lands in the area.

2.92 Reptiles. At least 40 species of reptiles are found within the study area. Most of the species reported from the area are common in occurrence and none is considered to be rare or endangered. The reptiles include 6 species of turtles, 8 species of lizards, and 25 species of snakes. Of particular interest is the widespread distribution of three species of rattlesnakes throughout this area, with the most common one being the diamondback rattlesnake. One other poisonous species that is not uncommon in some areas is the copperhead. The only species that is considered to be uncommon in this area is the Great Plains ratsnake, which is found in open woods, rocky hillsides, or fields. Although rare in this region, it is common throughout most of its' range which is the southern Great Plains.

2.93 Mammals. The upstream study area includes the range of at least 36 species of mammals. The mammals occurring in this area are fairly common species and widespread throughout the area. Various species of rodents comprise nearly one-half of the species present in the area. These are most commonly found associated with the grasslands and brushlands. The black-footed ferret, an endangered species and officially listed on the United States List of Endangered Fauna (Fish and Wildlife Service, 1974) may occur in the northern part of the study area in Oklahoma; however, the known range of this species is currently thought to be the High Plains of Texas and Oklahoma. It is usually found in association with prairie dog colonies because the prairie dog is its primary food. Prairie dog colonies are found in Beckham, Greer, and Harmon Counties, Oklahoma, so it is possible that the black-footed ferret is present in these areas. The major big game mammal is the white-tailed deer which is found primarily in the wooded areas of the region.

2.94 Invertebrates. The streams in the study areas support small invertebrate populations. Fish Creek (Area VI) in Greer and Beckham Counties of Oklahoma has a more diversified fauna than any of the other streams in the project areas because the quality of the water is better in this stream. Dry Salt Creek (Area XIV), in Childress and Collingsworth Counties, Texas, is dry for most of the summer except for a few shallow pot-holes which are also likely to be dry during the many extended dry periods that occur in this region.

2.95 Crayfish are present in Salt Creek (Area XIV) in Childress County above the salt area, but not in or below the salt source. Fish Creek in Oklahoma supports a population of aquatic insects, crayfish, and one species of snail. The stream margins are breeding places for horse flies and deer flies which are extremely abundant at times. Larval forms of these flies are found in the sand and mud along the stream margins. Mosquitoes are relatively common in the study areas. There are many stock ponds near all of these study areas that provide breeding sites for the mosquitoes. The most common invertebrates in the streams are naiads of the dragonflies and damselflies. Stoneflies, mayflies, and caddisflies occur in the upper portion of the North Wichita River (Area VII) above the salt source.

2.96 No unusual or rare invertebrates inhabit the tributaries of the Red River above Denison Dam.

2.97 The Wichita River system (Areas VII, VIII, and X) in the region of this project has a relatively small invertebrate population, probably due to the high salt content of the water. Most of the invertebrate fauna that is present consists of crustaceans and insects.

2.98 The crayfish, *Procambarus simulans*, is present in all three branches of the Wichita River. Amphipods are present in all three streams, and calanoid copepods are present in the middle and south forks of the river.

2.99 The most common invertebrates in the tributaries of the Wichita River are insects, including water scavenger beetles, damselflies, dragonflies, water striders, and midges. Adult mosquitoes were also common along the streams. Horseflies and deerflies were common along the streams and probably breed in the mud along the shorelines.

2.100 Birds. At least 230 species of birds are found in this area at some time or other. Considerable numbers of waterfowl migrate through the general area and use farm ponds for resting and feeding. Geese also use upland grain fields for feeding areas. Sandhill cranes overwinter in the region and utilize the bottomlands along the streams. Many species of shore and wading birds are common year round.

2.101 Quail and dove are the most abundant and sought after game species. Wild turkeys are also present in small numbers. The southern bald eagle and the American peregrine falcon, listed on the United States List of Endangered Fauna (US Fish and Wildlife Service, 1974) are likely to occur as winter residents or migrants throughout the general area.

2.102 Recreation. Thin population, low income levels, and an extended period of population decline have inhibited the development of public or commercial outdoor recreation facilities. The local climate has both positive and negative influences upon outdoor recreational activity. Outdoor activity is only briefly inhibited by winter cold, and snowfall is usually light and of brief duration. Wind chill can be severe, although extreme temperatures seldom drop below zero. On the other hand, mid-summer days may become extremely hot with maximums over 100°F. Extreme heat and high temperatures accompanied by high humidity will generally restrict outdoor recreation to water-contact activities, at least during the midday hours.

2.103 Game birds and animals constitute a high quality recreational resource. Quail and dove are the major game birds, with waterfowl of considerably less importante due to limitations in habitat and limited public access to suitable water areas. Along certain stream valleys wild turkeys are present and are hunted with increasing frequency. In Cottle County the Texas Parks and Wildlife Department administers the 28,183-acre Matador Wildlife Management Area where public hunting of dove and quail is permitted. On this refuge the demand for quail hunting is such that it must be limited by a permit drawing system. Extensive upland game habitat provides a potential for expanded hunting activity, although such expansion would require greater hunter access to private farm and ranch lands or additional public lands open to hunting.

2.104 The 1969 US Census of Agriculture listed a total of 30 farms or ranches in the seven counties which received income from providing recreational services. Income from these services averaged over $2,200 per farm. The census does not list the enterprises involved, but hunting fees or fees from farm pond fishing would be the most likely services. Between 1964 and 1969 the total number of farms and ranches providing commercial recreational services increased from 21 to 30, which was accompanied by a much sharper rise in the income per farm or ranch.

2.105 Water Recreation. Swimming pools are found in the larger towns and additional swimming opportunities are available in several area lakes. Stream recreation (bathing or fishing) is limited by seasonal fluctuations in flow and many small streams dry up completely during the summer months. Most of the surface water in the immediate area is found in small impoundments from five up to forty acres in size. The accessibility of these waters for public use varies since most of the ponds are on private lands. Some are available for fishing or water sports on a fee basis, but many are limited to the owner's family and friends or reserved for club use. Larger water bodies include the 6,575-acre Altus-Lugert Reservoir in Greer County, Oklahoma; Baylor and Childress lakes in Childress County, Texas, and Lake Kemp in Baylor County, Texas. Baylor Lake has a surface area of approximately 600 acres. Childress Lake has a maximum area of

175 acres but it has been dry in recent years. Beyond the immediate study area, Foss Reservoir northeast of Elk City, Oklahoma, provides water recreation on several thousand acres. North of Clarendon in Donley County, Texas, the 1,990-acre Greenbelt Lake is located on the Salt Fork of the Red River and within reach of many area residents. Still farther afield, Lake Meredith on the Canadian River and Lake Stamford, Lake Fort Phantom Hill, Lake J. B. Thomas, and White River Lake are the larger lakes which can be reached for weekend recreation.

2.106 Scenic and Historic Resources. Scenic resources consist of small town and farm landscapes, rolling brush and range lands, stream valleys, and river bluffs. The rural character of the area makes it possible to find, in some areas, landscapes little touched by man. Scenic values are generally unobtrusive and may be viewed as picturesque, restful, or monotonous depending upon the individual taste. Historic sites emphasize early settlements, cattle trails, railroad construction, and pioneer ranch holdings, such as the Mill Iron or the OX ranches. A number of historical markers are found along highways and road-side parks.

2.107 Sports Activity. The larger communities provide space for outdoor game activity on playgrounds, baseball fields, tennis courts, and golf courses. Public school grounds and practice fields are also important sources of play space, and in some of the smaller communities they may provide the only maintained game areas or spectator sport opportunities. Many communities also have fairgrounds or rodeo arenas.

2.108 Picnicking and Camping. Picnicking and camping facilities are not extensively developed, and are found mainly in city parks, at lake sites, and as transient facilities near main roads. A county park, being developed along the Salt Fork of the Red River north of Wellington, Texas, will add new facilities on 25 acres. The largest development is Quartz Mountain State Park on Lake Altus in Oklahoma. The newly developed Copper Breaks State Park in Hardeman County, Texas, just south of Quanah, will eventually provide 30 to 40 campsites and numerous picnic opportunities within a short drive of the project area.

2.109 Other Activities. Many other outdoor activities such as motorcycling, bicycling, horseback riding, target shooting, hiking, and nature study engage the residents of this area. These activities, especially hiking, bicycling, and nature study, are increasing in popularity nationwide and can be expected to require increased opportunities in the study area as well. No inventory could be found of vacation farms or ranches, although some of those listed in the 1969 agricultural census as providing recreational services may have been of this type. A new multipurpose resort, the Hay Camp Country Club, has recently opened in southeast Collingsworth County on a tributary of the Salt Fork of the Red River. The Club is located on about 1,000 acres and provides a wide range of recreational facilities to members. A membership fee and monthly dues support this operation. Facilities include about 150 acres of water area and a swimming pool. Plans provide for construction of a restaurant, club house, golf course, picnic areas, campgrounds, tennis courts, and riding trails. Membership is drawn mostly from a 75-mile radius with a few members from much greater distances.

2.110 Archeological and Historical Sites. Prior to initiation of the Chloride Control studies there had been very little archeological field work conducted in the specific areas of the Wichita and Red River affected by the proposed project. There were no recorded sites in the vicinity of Area VI in Oklahoma, and a total of 79 recorded sites in Cottle, Childress, Hall, and Collingsworth Counties in Texas. As a result of the archeological reconnaissance by Dr. Jack Hughes, West Texas State University, a total of 112 sites were recorded in or near the project areas. Only one of these sites, 41HL-12, was recorded prior to 1973. The cultural stages represented by sites in the area range only from early archaic through Neo-American time although Paleo Indian complexes are known to be present in regions adjacent to the Chloride Control project areas. The sites appear to represent camp or quarry sites or a combination of the two. The sites are generally limited in size and only five of the sites appear to represent high concentration indicative of more intensive occupation.

2.111 None of the sites has been tested or evaluated for National Register potential and only portions of the specific areas affected by pumping stations and pipelines have been examined. As soon as funds are available, the known affected sites will be tested, additional survey work will be performed, and a plan of mitigation, if necessary, developed.

2.112 Historically, this general region has been an apparent crossroads area since the earliest European exploration in North America. West Texas State University has documented the known expeditions in the immediate vicinity. Between 1541 and 1599, there were three Spanish expeditions. Between 1786 and 1789 the area was visited by the Frenchman, Vial, and from 1800 to 1852 at least six separate Anglo-American expeditions were made.

2.113 The first scientific and systematic reconnaissance of the area was made in 1852 under the direction of Randolph Marcy. As stated by West Texas State University, "If any physical evidence remains of these explorers having been in a particular spot, it is bound to be limited to something like a metal object accidentally left on the trail. If such were found, it might or might not be possible to prove that it originated with any one of the explorers. Nothing was found at any of the Chloride Control projects." The Comancheros frequented this area up until about 1875,conducting trade with the Kiowa-Comanche Indians,but none of their distinctive camps have been located in the areas affected by any of the proposed projects.

2.114 During the latter part of the 19th Century, the area was frequented by bison hunters who were closely followed by ranchers, once the Indian and buffalo were gone from the area.

2.115 The National Register of Historic Places has been consulted and there are no registered sites affected by any of the proposed projects. After completion of the archeological testing, any sites of potential National Registry status will be so designated and coordinated with the Advisory Council on Historic Preservation and the State Historic Preservation Officers. The report prepared for the Tulsa District by West Texas University has been forwarded to the State Historic Preservation Officers, the State Archeologists, and the National Park Service.

Red River Below Denison Dam.

2.116 Geology. The lower Red River flows through the Gulf Coastal Plain which lies between sea level and 600 feet above sea level. The relief is comparatively small and is due chiefly to the dissection by streams of a gently sloping plain. Two subdivisions of this plain are apparent: (1) hilly regions and, (2) floodplain and terrace areas.

2.117 The hilly regions are composed of Cretaceous and Tertiary sediments. The hills stand from 100 to 200 feet above the river valleys. The stream drainage pattern in general is dendritic, but a series of low ridges or cuestas has resulted from the differential erosion of stratified, sedimentary rock formations. These ridges, except the northermost, extend approximately northeast-southwest across the Red River Valley and are known, from south to north, by the following names: Kisatchie Wold, Sulfur Wold, Saratoga Wold, and Lockesburg Wold. They are formed by the outcropping edges of the Catahoula (Miocene), Wilcos (Eocene), the Sabine, and Nacatoch Copper Cretaceous formations respectively.

2.118 To understand the sources for the Red River sediments, the rock formations which outcrop along the river and near it must be considered. Detailed and quantitative information concerning the minerals in these formations is available only for a few exposures. The rocks of the region range in age from Lower Cretaceous to Recent; all are sedimentary.

2.119 From the Trinity sandstone, which is exposed near the confluence with the Washita River, the Red River Valley traverses younger formations of the Gulf Region until it joins the vast alluvial, Mississippi River plain near Marksville, Louisiana. The great majority of the material in these formations was derived from pre-existing sedimentary rocks and, therefore, may be regarded as reworked material. The Cretaceous and Tertiary formations of the region contain nearly all the common varieties of sedimentary rocks, and they give certain prominent characteristics to the Red River sediments. The red color, which is usually bright, is immediately noticeable. The coloring matter is obtained partly from the Permian and Pennsylvanian rocks farther west, but the volume of ferruginous sediment is greatly augmented in Louisiana by the addition of iron oxides from various Tertiary formations which contain considerable quantities of iron bearing minerals such as glauconite, limonite, hematite, magnetite, and ilmenite. Ferruginous concretions are abundant in several strata of the Tertiary section. The high mica content of the midway silts, sands, and clays is notable, and their color is typically lighter than that of the later Tertiary groups.

2.120 The conglomerates and gravels of the region are predominantly chert, quartz, and iron oxides. The texture of the clastic sediments is relatively fine. Except for concretions, chiefly calcareous and ferruginous, pieces of cobble size are rare.

2.121 The structures of the region are dominated by the Sabine uplift, a broad, low dome with a northwest-southeast axis. It occupies a large area in northeastern Texas and northwestern Louisiana and adjacent portions of Oklahoma and Arkansas. Although the quaquaversal dips have low angles, from a fraction of a degree to a maximum of six degrees, the dome is the dominant structure over an area of approximately 19,000 square miles. The River, which flows in a southeasterly direction across the center of the uplift, crosses the Tertiary Formations on its north flank in southwestern Arkansas, and traverses the same formations in the reverse order on the south flank in central Louisiana. Southeast from Grande Ecore the dip decreases gradually towards the Gulf of Mexico.

2.122 Water from natural sources contains mineral constituents dissolved from the rocks and soils of the earth's crust. The kind and quantities of dissolved minerals in surface water depend upon a number of environmental factors.

2.123 The length of time the water is in contact with the soil and rock is also important. The amount of minerals in the soil and rocks available for solution is decreased by leaching; therefore, in areas of high rainfall, rocks that originally contain large quantities of readily soluble minerals have been leached by circulating water until the mantle rock and residual soil contain relatively small amounts of readily soluble materials. These rocks usually yield water of low mineralization. However, in arid or semi-arid regions, most soils and the rocks from which they originated, are incompletely leached and still contain large amounts of readily soluble material.

2.124 Vegetation. The natural vegetation of the Red River Basin below Denison Dam is described herein. Vegetation types are used to designate the assemblages of plants in a given area and on a large geographical scale delineated by regions of similar climate. With the exception of the coastal pine forests, the communities described are those that represent the climax. No attempt is made to describe the seral changes. The coastal pine forest is of interest because, if left undisturbed, the associated hardwood species would replace the shade intolerant pines. Fire prevents this takeover, whether it be natural in origin or due to management practices. Nevertheless, most botanists consider fire a prevalent phenomenon and thus include the pine forests as natural vegetation for the area. Another situation worth mentioning is the change associated with overgrazing. Under grazing pressure the natural prairie vegetation becomes altered with a consequent change in species composition.

2.125 The upland vegetation is variable and generally is a function of precipitation. On a west-east gradient there is an increase in the annual amount of rainfall, plus a more even distribution of precipitation. The dominant vegetation changes accordingly integrating from short grass prairie in the west to deciduous forest in the east.

2.126 The transition from grassland to forest is represented by the Cross Timbers of Texas and the Post Oak Savanna of Oklahoma. The area is rolling to hilly, surface drainage is rapid, and soils are light colored, acid sandy loams and sands. Scattered throughout this portion of Texas are heavy clays which support a tall grass prairie. It is the edaphic factors, particularly those affecting soil moisture, which are responsible for the relatively sharp boundaries between these vegetation types. A sparse overstory of post oak and blackjack oak is the characteristic feature. The understory is typical bunch-grass dominated by little bluestem. Associated with the oaks is black hickory often mixed with winged elm, winged sumac, red bud and coral berry. The herbaceous cover is much reduced in certain areas probably due to the influence of fire and overgrazing. With this reduction in biomass preventing the accumulation of sufficient fuel and a reduction in fire frequency, the oaks become more dense creating a woodland condition.

2.127 The majority of the remaining vegetation has received various classifications, from that of a single association, oak-pine to one consisting of numerous combinations of oak and pine species. Based on the principal pine component, two forest associations can be distinguished. One association occupies eastern Oklahoma extending into Arkansas and is termed the Oak-Shortleaf Pine association. The pinewoods of eastern Texas and Louisiana consist of Oak and Loblolly Pine. The boundary between the two is determined by comparing the species distribution through the midwest.

2.128 The northern forest is classified an Oak-Hickory Association. The representative oaks are post, blackjack, black and northern red. In the western fringe the dominant species are blackjack oak, post oak, with sizable amounts of black oak and black hickory. Arborescent species include winged elm, mockernut hickory, and Northern red oak. Eastward oaks are joined by shortleaf pine as a dominant. Black oak reaches its best development on level uplands and hillsides where the soils are of good moisture content whereas blackjack and post oaks occupy the drier sites. The soils of blackjack oak can be characterized as being very coarse whereas, post oak exhibits a wider ecological amplitude. Shortleaf pine can grow on a great variety of soils but best growth is in fine sandy loams or silt loams. It is more abundant than loblolly pine on the drier, better drained, and lower nutrient soils.

2.129 The forest region of Texas and Louisiana is termed a pinewoods and consists principally of loblolly pine. Other species include longleaf pine, slash pine, oaks, hickories, and red maple. Loblolly pine grows on a wide variety of soils, but is a particularly good competitor on soils with poor surface drainage, a deep surface layer, and a firm subsoil.

2.130 Both oak-pine associations exhibit similar understory species. Huckleberries, greenbriar, holly, gooseberry, buttonbush, and French mulberry are present, to name a few. There are many lianas, ferns, and shade-tolerant herbs. Forage plants predominately are species of Andropogon, Schizachyrium, Panicum, Sporobolus, and Eragrostis.

2.131 The final association occurs in Louisiana near the junction of the Red River and the Mississippi River. The physiognomy is a tall forest of broadleaf deciduous trees and evergreens. The dominant hardwood species are beech, sweet gum, southern magnolia, and laurel oak. Associated evergreens are primarily loblolly pine, and secondarily slash pine. Other components include southern red oak, flowering dogwood and an assortment of hickories.

2.132 The lowland vegetation within the Basin has not been studied extensively and relatively little information is available. Below Lake Texoma, the lowland forest include more species with willow and cottonwood adjacent to the stream and green ash, hackberry, pecan, walnut, black gum, and water elm occurring on the first terrace.

2.133 Along the Red River in Louisiana, the flood plain may be very broad and characterized by swamp forests. These communities are dominated by tupelo gum, bald cypress, water elm, red maple, pumpkin ash, water ash and several species of oaks.

2.134 Fauna. The following pages describe the faunal elements of the Red River Basin below Denison Dam, but major emphasis is placed on the river habitat itself.

2.135 In attempting to delineate reaches for the Red River fauna, natural biotic realms were used for reaches (Table 2-4). The faunal biotic reaches of the Red River are defined as: Reach 1. Llama Estacoado, Reach 2. Low Plains, Reach 3. Lake Texoma, Reach 4. That portion of the Red River between Denison dam and the western limits of McCurtain County, Oklahoma, Reach 5. Kiamichi-Ouachita Province of southeastern Oklahoma and southwestern Arkansas, Reach 6. Coastal Plains Province of southeast Oklahoma, northeast Texas, southern Arkansas, and most of Louisiana, and Reach 7. Coastal Marsh, Atchafalaya River Basin south of U.S. Highway 190 bridge between Opelousas and Baton Rouge, Louisiana. The fauna of reaches 1 and 2 have been discussed previously and therefore the following pages will consider only reaches 3 through 7.

TABLE 2-4
Natural Biotic Reaches of Red River

Reach Definitions

| | |
|---|---|
| Reach No. 1. | Llano Estacado or High Plains of Texas Panhandle. |
| Reach No. 2. | Low Plains. This reach includes territory from eastern escarpment of Reach No. 1 eastward to Lake Texoma (Reach No. 3) of Oklahoma and Texas. |
| Reach No. 3. | Lake Texoma. |

TABLE 2-4 (CONT)

| | |
|---|---|
| Reach No. 4. | That portion of Red River between Denison dam and western limits of McCurtain Co., Oklahoma. |
| Reach No. 5. | Kiamichi-Ouachita Province of southeastern Oklahoma and southwestern Arkansas. |
| Reach No. 6. | Coastal Plains Province of southeast Oklahoma, northeast Texas, southern Arkansas, and most of Louisiana. |
| Reach No. 7. | Coastal Marsh. Atchafalaya River basin south of U.S. Highway 190 bridge between Opelousas and Baton Rouge, Louisiana. |

2.136 Fishes. Approximately 171 species of fishes are found in the waters of the Red River Basin including the two upper reaches. Of this number, eight species are regarded as indigenous and 18 as economically important; that is they are actively pursued for sport, food, and bait. In addition several exotic species have been established as the result of introduction by man. Most of these introductions, originally in impoundments for food, sport, bait, or as forage for game fishes, have greatly extended or modified the known ranges of some species. Introduced species include carp, goldfish, grass carp, rainbow and brown trout, northern pike, muskellunge, mexican tetra, striped bass, and walleye.

2.137 Prior to the construction of Denison Dam and filling of Lake Texoma (Reach No. 3) in 1942, the numbers of species in the Red River gradually increased between Reach No. 2 and the western limit of Reach No. 6. When the Denison Dam was completed, the lake dramatically altered the physical character of the river and composition of its fish fauna. The lake began to function as a settling basin for the suspended solids transported by streams of Reach No. 2, and as a diluting agent for entering dissolved solids. As a result, many of the riverine fish species adapted to turbid and semi-saline lotic environments disappeared or were replaced by lentic species. The river below Denison Dam (Reach No. 4) was transformed from a turbid river with high salinity and irregular flow-rate to a relatively clear river with low salinities and a more or less constant flow-rate. Correspondingly, those fish species adapted to the first set of environmental conditions were reduced in numbers or replaced when the river's physical characteristics were modified. Thus, although the total number of species shows a gradual increase from Reach 2 to Reach 4, species composition of each reach is different.

2.138 Reach No. 5 is geologically and biologically very different from any of the other reaches. This reach is typically mountainous with many clear lakes and streams. The streams are generally fast to moderate-flowing, cold and characterized by rock or gravel bottoms. Because this reach is different, it is not surprising that its fish fauna is large (approximately 124 species) and that some are recognized as endemic. Of the eight endemic species in the Red River Basin, six are restricted to this reach or shared with adjacent parts of Reach No. 6. The endemic species are colorless shiner, Ouachita madtom, Caddo madtom, starhead topminnow (this form is being redescribed as a new species), Paleback darter, and edfin darter.

2.139 Reach No. 6 extends from southeastern Oklahoma (McCurtain Co.) southeastward to the Atchafalaya River basin near the U.S. Highway 190 bridge west of Baton Rouge, Louisiana. The Red River no longer flows into the Mississippi River near Simmesport, La. since it has been artificially diverted into the Atchafalaya River. Reach No. 6 which consists of the Archafalaya River and the Red River, is typified by slow-flowing, meandering, sandbottom streams and numerous swamps, marshes, and oxbow lakes. Because the aquatic habitats are more and varied, the number of fish species is correspondingly greater (approximately 135). In Reach No. 6 there is one endemic species, the blacktail shiner and several other endemics which are shared with Reach No. 5 (see comments below).

2.140 Reach No. 7 includes the Atchafalaya River and its delta. This reach is mainly gulf swamp and marsh, with most of the larger waterways defined by levees. Approximately 48 species of freshwater fishes are found here. This number should be regarded as conservative, for there are many estuarian and marine species which have not been included. Reduction in the number of freshwater species between Reaches 6 and 7 can be, in part, attributed to the fact that Reach No. 7 is periodically inundated by estuarian and marine waters (e.g. during hurricanes). Very few freshwater species of this reach can withstand sudden exposure to hypersaline situations.

2.141 Sport and Commercial Fisheries. Recreational and commercial fisheries are important in five of the seven reaches of the Red River Basin. Although sport fishing species occur in Reaches 1 and 2, their numbers are limited because of certain physical features of those reaches.

2.142 In Reach No. 3 the major game species are white bass, largemouth bass, potted bass, white and black crappies, various sunfish species, channel catfish, blue catfish, flathead catfish, and to a lesser extent striped bass, sauger, and walleye. Of these, the white bass, largemouth bass, spotted bass, channel catfish, and white and black crappies are the most important game species. The introduction of the striped bass and walleye in recent years has added significantly to the total sport fisheries of Lake Texoma (Reach No. 3). Until 1970, commercial fishing interests used to harvest annually large quantities of "rough fish" from the lake; however, certain sport fishing organizations and fish and game agencies filed suit against the commercial fishers, because their netting practices allegedly indiscriminately destroyed large numbers of game species, especially Striped bass. Thus, most commercial fishing in Lake Texoma has ceased.

2.143 As in Reach No. 3 important sport fishes of Reach No. 4 are White bass, largemouth bass, spotted bass, channel catfish, white and black crappies. In this reach, most of the sport fishing occurs in the tail waters and raceway immediately below Denison Dam. No information is available on commercial fishing activities.

2.144 In Reach No. 5 the economically important species are largemouth bass, smallmouth bass, spotted bass, white bass, white and black crappies, sunfishes, rainbow and brown trout, flathead catfish, walleye, sauger, northern pike, and muskellunge. The largemouth bass, spotted bass, white bass, and two crappie species are the principal sport species in the many lakes of the region. The mallmouth bass is perhaps the most important riverine sport fish although in selected areas (e.g. below Blakely Mountain dam, Ark.) a put-and-take trout fishery exists. In recent years, various state fish and game agencies have introduced walleye, sauger, muskellunge, and striped bass in many reservoirs of the area; yet, to date, such introductions have provided only a limited fisheries. No information is available on commercial fishing activities in Reach No. 5.

2.145 In Reach No. 6 the principal sport fishes are Largemouth bass, white bass, spotted bass, black and white crappies, and various sunfishes of the genus Lepomis. This region supports a tremendous sport fisheries; most sport fishing is confined to oxbow lakes and back water areas along the Red River and its tributaries, however. This reach also supports a large commercial fishing industry. Like the sport fishermen, most commercial fishermen generally confine their activities to oxbow lakes and river backwaters. Species most commonly caught commercially include catfishes, buffalo fishes, freshwater drum, gars, carp, shad, paddlefish, and bowfin.

2.146 Incomplete data from the U.S. Department of Commerce revealed that parishes in the lower Red River drainage had an average annual commercial fish catch of 981,350 pounds for the period 1968-1971. This represented an average annual wholesale value of approximately $140,000 and a retail value of four or five times that amount. Fish studies conducted in 1957 by Louisiana Wildlife and Fisheries Commission personnel indicated that the backwater overflow areas in the north delta (specifical Avoyelles and Rapides parishes) produced an annual commercial fish harvest of approximately 2,800,000 pounds of fish valued in excess of $833,000. This same area supported an extensive sport fishery for largemouth bass, spotted bass, white bass, white and black crappies, and various sunfishes (Lepomis spp.) that annual harvested nearly 1,700,000 pounds of sport fish. In recent years, extensive levee construction, land clearing and operation and widespread cropdusting activities have significantly reduced the annual harvest of commercial fishes. As more streams and lakes are converted into canals for navigation and areas cleared and drained for farming, some fish populations will decline further.

2.147 <u>Amphibians</u>. Of the 55 species and subspecies of amphibians found in the Red River Basin, two salamanders are endemic (Caddo Mountain salamander (<u>Plathodon caddoensis</u>) and Rich Mountain salamander (<u>P. ouachitae</u>) both of which are restricted to Reach No. 5. <u>P. ouachitae</u>, however, is restricted to the Rich Mountain area of southeastern Oklahoma.) The greatest number of species are found in Reaches 4-7, since these reaches have a greater abundance of water and wider variety of aquatic habitats. The bull frog is found throughout the basin and, in some localities (especially in Reach 6-7), it is hunted for sport and grown commercially for food.

2.148 Reptiles. In the Red River drainage there are approximately 124 species and subspecies of reptiles of which 25 are turtles, 25 lizards (including the lligator, a lizard-like form), and 74 snakes. Two species (snapping turtle and the alligator) are of limited economic value and the two species (alligator and Atlantic ridley (Lepidochelys kempi)) are recognized as rare and endangered. The napping turtle is widely collected in parts of Louisiana and Arkansas and locally sold for food. The Alligator, currently listed as a game species by the State of Louisiana, is harvested during a limited hunting season for its hide. All other states still recognize the alligator as an endangered species; thus, stringent laws have been enacted to guard against its being illegally poached for its hide. The Atlantic ridley, a marine species, is being artifically re-established along certain portions of the Louisiana and Texas Gulf coasts. The success of this endeavor will not be known for years to come.

2.149 There are several other reptilian species of lesser economic importance; that is, many are poisonous (e.g. species of the genera Akgistrodon, Sistrurus, Crotalus, and Micrurus), hunted illegally for sale to some zoos and reptile clearing houses, or collected for their venoms for use in the production of snakebite serums.

2.150 Birds. Approximately 380 species of birds have ranges which include parts of the Red River Basin. Of these, 45 species are economically important and 7 recognized as rare and endangered.

2.151 Since birds are mobile over large geographical distances, discussion of ranges is meaningless without dividing birds into various migrant and nonmigrant groups. Five different categories have been established: (1) Migrant - A bird which passes through a reach during migration, but which is not considered a summer or winter resident. (2) Permanent Resident - A bird which is nonmigratory in a reach. (3) Summer Resident - A bird which inhabits a reach only during the summer (breeding may or may not take place therein). (4) Winter Resident - A bird which inhabits a reach only in the winter, and (5) Occasional - A bird which is an irregular visitor to a reach.

2.152 The migrant constitutes by far the largest single category. This is undoubtedly the result of the Red River Basin transcending several of the major continental flyways, viz., Central, Mississippi and Coastal flyways. Also, the basin extends far enough to the west that western species of birds are encountered as Occasional in Reach No. 1.

2.153 Principal economically important migrants include ducks (especially species of Anas), geese (Anser, Branta, Chen), and whooping crane. The whooping crane, though not a game bird, is considered an important form, because it is endangered and annually attracts large numbers of amateur and professional ornithologists. Although data are not available, expenditures by ornithologists to view this bird on the Aransas Wildlife Refuge, Texas, are substantial. Of course, ducks, geese and their allies are economically important, for they form the bases of tremendous hunting industries in parts of Arkansas and Louisiana (Reaches 5-7).

2.154 There are approximately four times as many migrant species as permanent residents per reach of the Red River Basin. Reaches 2 and 7 have the highest number of permanent residents (51 and 49, respectively) because these reaches are ecotonal regions. An ecotone is a transitional zone between major biotic realms, or biomes; therefore, it offers habitats common to each of its biomes. Reach No. 2 is an ecotone between the prairie and eastern deciduous forest. Likewise, Reach No. 7 is an ecotone between the terrestrial, marsh, swamp, and forest environments of the Atchafalya delta and the Louisiana Gulf Coast.

2.155 Gallinaceous game birds are the major economically important permanent residents in the basin. These birds are primarily inhabitants of grassland and open forests. Five species are common to the basin, viz., bobwhite, scale quail, coturnix, ring-necked pheasant, and turkey. Although Gallinaceous game birds are found throughout the basin all five species are found in and are important to the prairie regions of Reaches 1 and 2.

2.156 Winter residents are generally more abundant and more diversified in the southern portions of the Red River Basin (Reach No. 7), while summer residents exhibit greater numbers and diversity toward the northern extremities of the basin (Reaches 2-6). During the winter, the number of economically important species dramatically increases. This is attributed to the tremendous influx of migratory water birds (especially duck and geese), which use extensive portions of Reaches 6 and 7 for winter resident quarters. In recent years however, total numbers of these game birds have decreased because a substantial portion of their summer nesting habitat in Canada and wintering habitat in Louisiana is being destroyed. In addition, construction of large reservoirs throughout the Plains States, plus feeding practices by farmers of that region have also contributed to this decline.

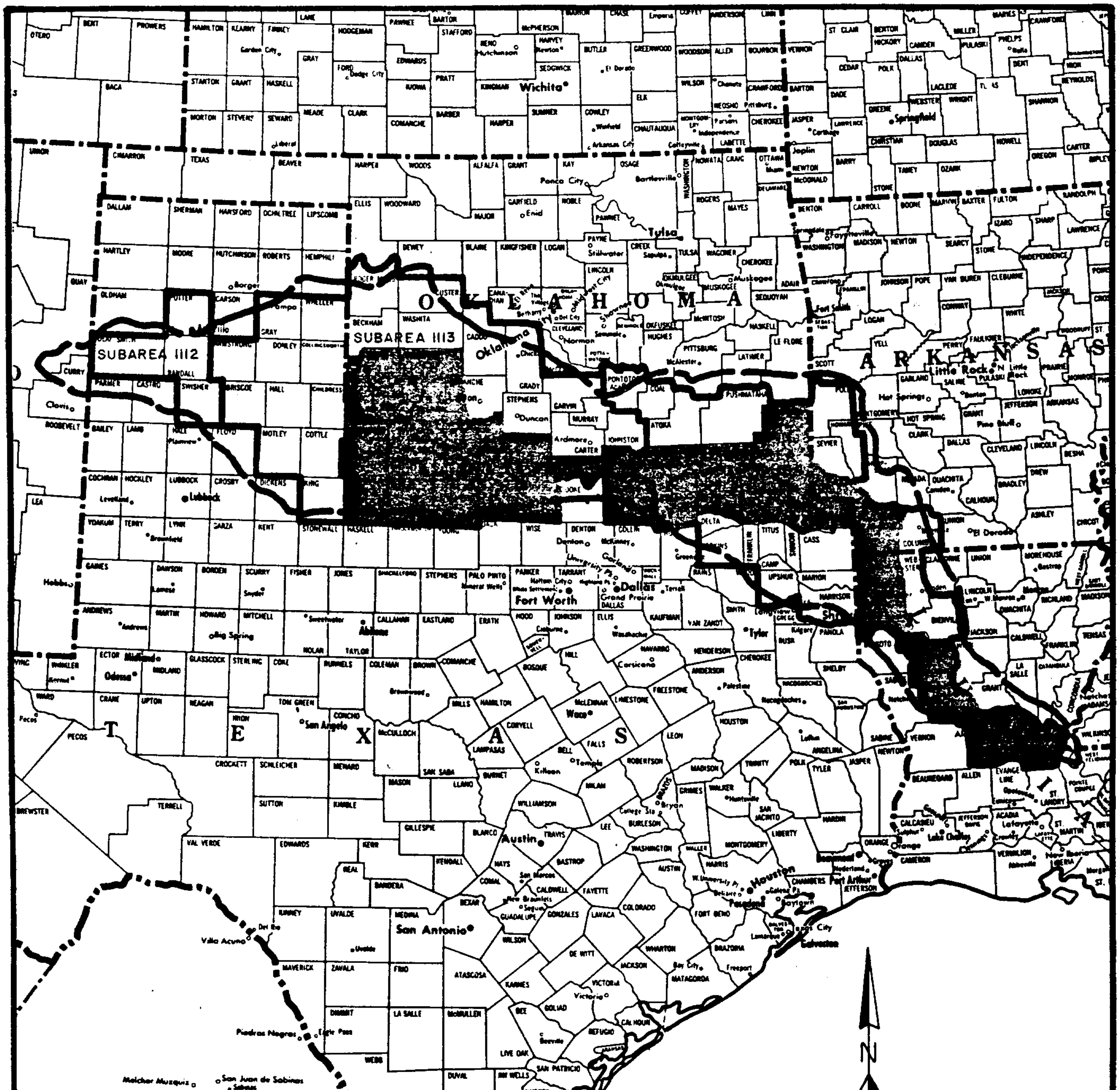
2.157 Of the rare and endangered forms, five are considered endangered and on the verge of extinction, even though some have shown increases in numbers in recent years. The endangered forms include American Peregrin falcon (Falco peregrinus anatum), greater prairie chicken, whooping crane, Eskimo curlew, and ivory-billed woodpecker. If it exists at all, the ivory-billed woodpecker is the rarest bird in North America.

2.158 The golden-cheeked warbler is considered rare and Bachman's warbler is considered depleted. The rufous-sided towhee was listed as rare and endangered, but is no longer recognized as such.

2.159 Mammals. Approximately 97 species of mammals are found within the limits of the Red River basin. Of this number, 26 are economically important and three considered as rare and endangered. Those mammals that are considered economically important include game species, potential disease vectors and/or pests, e.g., Norway rat, and those that were once exploited for their pelts or as food, but which are now maintained only in refuges, e.g., elk and bison. The rare and endangered species are: Indiana myotis, whose total range has been dramatically reduced in recent years; black-footed ferret, which has been almost exterminated because of population control measures being stringently applied to its prime food source, the blacktail prairie dog; and red wolf, whose habitat has also been significantly reduced in recent years.

2.160 Social and Economic Considerations. The downstream study area is composed of 35 contiguous counties located in the Red River Basin (Figure 2-1). Fourteen of the counties are located in Texas, twelve in Oklahoma, six in Louisiana, and three in Arkansas. Below are the counties in the study area listed according to state:

| State | County or Parish |
|---|---|
| Arkansas | Lafayette |
| | Little River |
| | Miller |
| Louisiana | Avoyelles |
| | Bossier |
| | Caddo |
| | Natchitoches |
| | Rapides |
| | Red River |
| Oklahoma | Bryan |
| | Choctaw |
| | Cotton |
| | Greer |
| | Harmon |
| | Jackson |
| | Jefferson |
| | Kiowa |
| | Love |
| | Marshall |
| | McCurtain |
| | Tillman |
| Texas | Archer |
| | Baylor |
| | Bowie |




*LEGEND*

BOUNDARY OF RED RIVER BASIN

BOUNDARY OF WRC SUBAREAS

STUDY AREA
RED RIVER BASIN
AND WRC SUBAREAS
EXCLUDING THE
OUACHITA BASIN



Figure 2-1

| State | County or Parish |
|---|---|
| Texas (continued) | Clay |
| | Fannin |
| | Foard |
| | Grayson |
| | Hardeman |
| | Lamar |
| | Montague |
| | Red River |
| | Wichita |
| | Wilbarger |

2.161 Population. Population of the study area was 1,124,833 inhabitants in 1970, an increase of 2.3 percent from 1960 (Table 2-5). The study area's most populous county in 1970 was Caddo Parish, Louisiana with 230,184 people. Wichita County, Texas, and Rapides Parish, Louisiana were ranked second and third with populations of 120,563 and 118,078 respectively. The remaining 32 counties had populations ranging in size from 83,225 inhabitants in Grayson County, Texas, to 3,125 inhabitants in Foard County, Texas. The study area's population is projected to grow to 1,860,700 inhabitants by 2020, an increase of 65 percent from 1970. This represents an average annual increase of 1.01 percent over the 50-year period.

2.162 Population density of the study area was 38.6 persons per square mile in 1970. Caddo Parish, Louisiana, is the most densely populated with 256.0 persons per square mile. Wichita County, Texas, and Rapides Parish, Louisiana, rank second and third with 197.3 and 89.6 persons per square mile,respectively. The remaining 32 counties range from 88.5 persons per square mile in Grayson County, Texas, to 3.3 persons per square mile in Foard County, Texas. Density is projected to reach 63.8 persons per square mile in the study area in 2020.

2.163 Employment. Total employment in the project area projected to the year 2020 is shown in Table 2-5. In 1970, total employment was 385,756, or roughly 34 percent of the study area population. Employment is projected to grow at a higher rate than population over the period of analysis, reflecting the rising trend in labor force participation rates which has occurred over the past few years. Participation rates are expected to grow at an increasing rate in future years due, mainly to the decrease in population growth, and to greater participation by females in the labor force. Total employment in the year 2020 is projected to be 738,000, or about 40 percent of the population in that year.

2.164 Income. Per capita personal income in the study area was $2,938 in 1972, which is about 79 percent of the national average for that year. By 2020 per capita income is projected to reach $11,702, about 82 percent of per capita income in the nation in the year 2020, as projected by OBERS.

2.165 Business and Industry. Agriculture, manufacturing and mineral industries are three leading industry groups in the study area's economy. Projections of their respective contributions to the region's income are shown in Table 2-5.

2.166 Agricultural activity is relatively evenly dispersed over the study area. Major crops include wheat, cotton, hay, soybeans, and sorghum. Livestock, however, is the principle revenue producer in the area, accounting for about 60 percent of the value of farm products sold in 1969. The value of farm products sold is projected to increase to $696 million by 2020, an increase of 121 percent over the 1969 figure of $315 million.

2.167 Manufacturing activity in the study area is much more concentrated, geographically, than agriculture. Over three-fourths of the area's 1972 Value Added by Manufacture was produced by six counties. These counties contain the cities: Alexandria, Shreveport, Texarkana, Paris, Sherman, and Wichita Falls. The major product groups manufactured in the study area include fabricated metal products, machinery, and chemical and allied products.

2.168 It is anticipated that manufacturing will play an increasingly important role in the future. Value added by manufacture is projected to be almost $6 billion by the year 2020 - almost seven times the 1972 value. Both increased employment and improved productivity should contribute to this growth. Fabricated metal products and electrical machinery are expected to account for the major portion of this increase in output.

2.169 Almost all of the study area counties reported mineral production in 1972. The leading minerals produced in the area are petroleum, natural gas, and natural gas liquids; however, sand and gravel, stone, cement, clays, gypsum, and small amounts of copper, silver, and zinc are also mined. The value of mineral production is projected to increase to $477 million in 2020, more than double the 1972 value.

2.170 Public Services and Health Status. An increase in the water quality of the Red River will give municipalities the potential to provide public services at a lower cost to residents. Potential water supplies will be increased, and expenditures on plant equipment damage due to corrosion will decrease. Health status of the study area will be improved by the municipal water quality increases. Populations can grow without as great a threat of water shortage and its consequences which include rationing and higher incidences of illness.

TABLE 2-5

SUMMARY OF ECONOMIC INDICATORS
RED RIVER CHLORIDE CONTROL PROJECT
STUDY AREA

| | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| Total Population | 1,124,833 | 1,210,200 | 1,486,200 | 1,860,700 |
| Population Density | 38.6 | 41.5 | 51.0 | 63.8 |
| Employment | 385,756 | 434,700 | 569,100 | 738,800 |
| Per Capita Income | $ 2,983 [1] | $ 3,951 | $ 7,065 | $ 11,702 |
| VAM (millions-1967$) | $ 877.5[1] | $ 1,235.5 | $ 2,859.7 | $ 5,950.4 |
| Value of Farm Products Sold (thou-1967$) | $315,036 [1] | $398,400 | $527,400 | $696,000 |
| Value of Minerals Produced (thou-1967$) | $235,976 [1] | $272,300 | $342,500 | $476,700 |

[1] 1972 figures

Source: Red River Chloride Control Project, Area Economic Study, Southwestern Division, US Army Corps of Engineers.

## Future Environmental Setting Without the Project

2.171 Even without the project, changes in the environment will occur. The plant and animal communities of the basin are expected to undergo marked changes because of the clearing of lowland forests for agricultural purposes, inundation as a result of dam construction, and channelization of streams. These changes will result in the alternation of aquatic and lowland communities usually by lowering the species diversity of the affected area. Species which are generalized in their habitat requirements will increase in number while species which have specialized habitat requirements will be reduced in number.

2.172 At the present time, less than 10% of the potentially irrigable land is irrigated. Without the project, it is not likely that irrigation practices will increase in the basin. If waters from the upper reaches of the Red River were used for irrigation, there would be a degradation of soil conditions because of the increased soluble salts added to the soil.

2.173 Since the economy of the area is based upon agriculture, there is little reason to expect a significant expansion of agricultural activity without an improved quality of water which would allow additional land to be irrigated. Present land use will be expected to prevail in the future under these conditions.

2.174 In the absence of the proposed project, no significant changes in water quality is expected to occur in the basin. Surface water will continue to be of a poor quality and unusable for agricultural, municipal, and industrial uses. Groundwater supplies will continue to decrease and diminish in quality because of the lack of aquifer recharge.

## SECTION 3 - RELATIONSHIP OF THE PROPOSED ACTION TO LAND-USE PLANS

3.01 Interagency coordination meetings were held in 1969 and 1970 to discuss the Red River Chloride Control Project and the supplemental studies which were to be conducted in conjunction with the planning studies. Representatives of concerned Federal, State, regional and local agencies were present. Four public involvement sessions were held in 1974 when alternative control plans were better defined. The purpose of those sessions was to inform the public of the status of the studies and to solicit their opinions and ideas. Many concerned agencies were represented at the sessions and actively participated in the discussion of alternative control plans. Based on information reported from these coordination meetings, public involvement sessions, and concerned individuals, no land use plans for the project area are known to exist.

3.02 The Red River Chloride Control Project as planned is in agreement with the regulatory concepts and policies of Federal, State, regional, and local planning agencies.

## SECTION 4 - THE PROBABLE IMPACT OF THE PROPOSED ACTION ON THE ENVIRONMENT

4.01 Impact on Streamflow and Water Quality. The principal goal of the project is the reduction of natural mineral pollution of waters of the Red River Basin by the removal of dissolved materials. It is estimated that the plan would remove about 45 percent of the approximate average of 3,300 tons of chloride that now reach Lake Texoma each day. This reduction of about 1,470 tons is made up of a reduction in the Red River Basin of about 1,110 tons and in the Wichita River Basin of about 360 tons. This reduction will enhance the quality of water in Lake Kemp, Lake Texoma, and downstream, thus providing water with acceptable chloride levels for municipal, industrial, and agricultural uses most of the time. The most obvious effect on streamflow as a result of the impoundments will be a reduction in quantity because of the evaporating impoundments and the quantity of water reaching Lake Kemp and Lake Texoma can be expected to be reduced by some additional factor because the improvement in water quality resulting from the removal of chlorides will encourage withdrawals of water from the streams prior to their entering the lakes. An illustration of water quality improvement as a result of the project is the following data on Lake Kemp. Existing and modified concentrations of chlorides, sulfates, and total dissolved solids in Lake Kemp, presented in Table 4-1, were taken from Lake Kemp routings. Lake Kemp water under existing conditions has chloride concentrations exceeding 1,000 mg/l 50 percent of the time, with peak concentrations exceeding 1,300 mg/l 2 percent of the time (Table 4-1). The lowest chloride conditions are reached during flood operations and average 780 mg/l or less 2 percent of the time. It is estimated that the chloride concentrations in Lake Kemp would be reduced to about 360 mg/l 98 percent of the time, in about 5 years after the plan is implemented. After about 20 years of operation, the chloride concentrations in Lake Kemp are expected to meet the standard set by the Environmental Protection Agency (EPA) 98 percent of the time (Table 4-2). Sulfates and total dissolved solids are not expected to reduce to the concentrations necessary to meet EPA standards. The project will degrade rather than enhance water quality in the parts of the drainage basins utilized as brine lakes. Not only will brine be transferred into an area where the surface waters are not highly saline, but the brines ultimately will be highly concentrated by evaporation. This should not be a serious deterrent, however, because the amount of land and the water involved is but a small fraction of the area and volume of water to be benefitted by this transfer and storage. The subsurface conduit cut-off systems for low flow brine collection will not alter the natural and orderly processes of systematic degradation and aggradation of the affected streams. It is possible that a shift in stream equilibriums (flow, velocity, and load) will develop but these effects should be minor in overall stream characteristics. At these sites, sediment entrapment should be slight and would be flushed out during periods of greater flow.

TABLE 4-1

EXISTING AND MODIFIED CONCENTRATIONS OF CHLORIDES, SULFATES AND TOTAL DISSOLVED SOLIDS AT LAKE KEMP

| CONDITIONS | CONCENTRATIONS (mg/l) Cl | $SO_4$ | TDS | PERCENT OF TIME CONCENTRATIONS ARE EQUAL OR LESS THAN |
|---|---|---|---|---|
| NATURAL | 1300 | 810 | 3520 | 98 |
| | 1040 | 640 | 2820 | 50 |
| | 780 | 490 | 2110 | 2 |
| MODIFIED | | | | |
| After 5 years | 350 | 450 | 1520 | 98 |
| After 20 years | 250 | 320 | 1080 | 98 |

TABLE 4-2

WATER QUALITY STANDARDS, PUBLIC HEALTH SERVICE AND EPA

| | MUNICIPAL | PETROLEUM REFINERY | THERMAL ELECTRIC PLANT |
|---|---|---|---|
| Cl, mg/l | 250 | 300 | 600 |
| $SO_4$, mg/l | 250 | No Limit | 680 |
| TDS, mg/l | 500 | 1,000 | 1,000 |

4.02 Projected Water Quality of the Red River. Water quality data are routinely collected in the Red River by the US Geological Survey and 20 years of records have been kept. Table 2-1 provides data, which are monthly averages during 1973 and 1974, from the Red River Stations for calcium, magnesium, sodium sulfate, chloride, and specific conductance. Clearly, by far the highest concentrations are in the upper approximately 150 miles; thereafter, the concentration gradient is low. For analytical purposes, chloride, sulfate, and total dissolved solid concentrations were selected. This choice was based on the similarity of behavior between the ions in streams, the anticipated impacts, and the fact that the project dealt with chloride control. The concentrations vary both through time and space. Therefore, the data in Tables 4-4 through 4-12 present concentrations by reach and also as a percentage of time the tabular value would be equalled or exceeded. The zero percent control represents the no project conditions and the 30, 60, and 90 percent control refers to the various levels of project implementation. The tabular values are the basis for the project comparisons and were calculated from data of the Corps of Engineers, Tulsa. The analytical reaches are presented in Table 4-3 and Figure 4-1.

TABLE 4-3

ANALYTICAL REACHES OF THE RED RIVER BY COUNTY *

| Reach No. | Oklahoma | Texas | Arkansas | Louisiana |
|---|---|---|---|---|
| I | Tillman | Wilbarger | | |
| II | Cotton | Wichita | | |
| III | Jefferson | Clay | | |
| | Love | Montague | | |
| | | Cooke | | |
| IV | Marshall | Grayson | | |
| V | Bryan | Fannin | | |
| | Choctaw | Lamar | | |
| | | Red River | | |
| | | Bowie | | |
| VI | McCurtain | | Miller | Caddo |
| | | | | Red River |
| | | | | Natchitoches |
| | | | | Rapides |

* The criteria used for establishing the reaches were that the particular reach be homogeneous in terms of environmental parameters and that the reach be anticipated to respond in a homogeneous manner to chloride control. The reaches extend from the head waters of the Red River to the Atchafalaya River Basin between Opelousas and Baton Rouge, Louisiana.

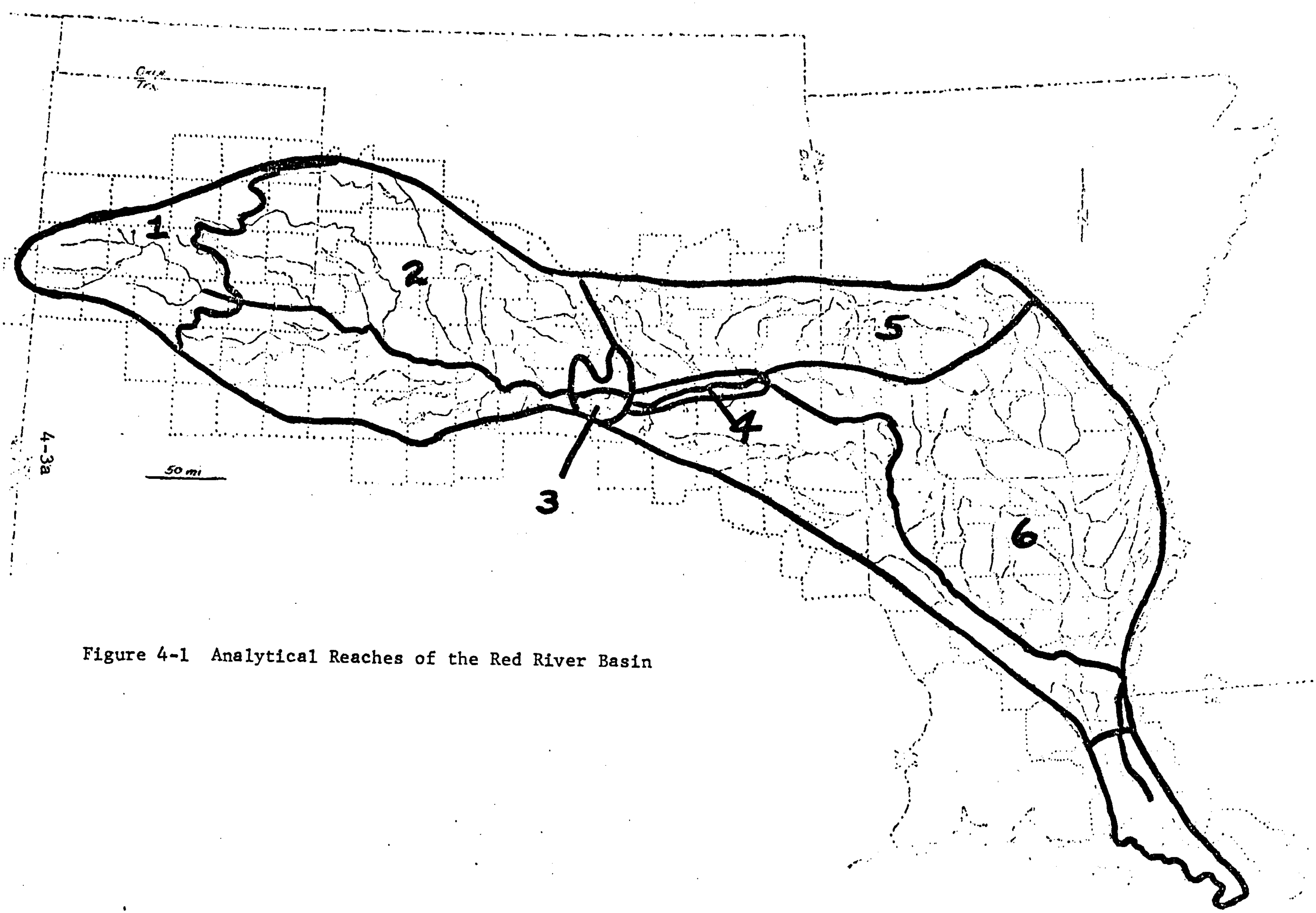



Figure 4-1 Analytical Reaches of the Red River Basin

TABLE 4-4

CHLORIDE CONCENTRATION OF RED RIVER, MG/L
(10% OF TIME EQUALLED OR EXCEEDED)

| | Percent Control | | | |
|---|---|---|---|---|
| REACH | 0 | 30 | 60 | 90 |
| I | 3,200 | 2,750 | 2,200 | 1,800 |
| II | 1,800 | 1,400 | 1,300 | 1,100 |
| III | 1,600 | 1,300 | 1,200 | 1,000 |
| IV | 440 | 360 | 270 | 220 |
| V | 370 | 305 | 235 | 195 |
| VI | 305 | 245 | 190 | 150 |

TABLE 4-5

SULFATE CONCENTRATION OF RED RIVER, MG/L
(10% OF TIME EQUALLED OR EXCEEDED)

| | Percent Control | | | |
|---|---|---|---|---|
| REACH | 0 | 30 | 60 | 90 |
| I | 1,400 | 1,300 | 1,200 | 1,200 |
| II | 970 | 860 | 860 | 830 |
| III | 750 | 700 | 680 | 610 |
| IV | 290 | 290 | 270 | 270 |
| V | 275 | 275 | 260 | 260 |
| VI | 195 | 195 | 180 | 180 |

TABLE 4-6

TOTAL DISSOLVED SOLIDS CONCENTRATION OF RED RIVER, MG/L (10% OF TIME EQUALLED OR EXCEEDED)

| | Percent Control | | | |
|---|---|---|---|---|
| REACH | 0 | 30 | 60 | 90 |
| I | 8,000 | 6,500 | 5,700 | 4,600 |
| II | 4,700 | 3,600 | 3,400 | 2,800 |
| III | 3,700 | 3,100 | 2,900 | 2,500 |
| IV | 1,200 | 1,050 | 880 | 790 |
| V | 1,200 | 1,025 | 900 | 820 |
| VI | 970 | 870 | 780 | 735 |

TABLE 4-7

CHLORIDE CONCENTRATION OF RED RIVER, MG/L (50% OF TIME EQUALLED OR EXCEEDED)

| | Percent Control | | | |
|---|---|---|---|---|
| REACH | 0 | 30 | 60 | 90 |
| I | 2,150 | 1,600 | 1,200 | 700 |
| II | 1,325 | 1,000 | 725 | 380 |
| III | 1,100 | 800 | 650 | 325 |
| IV | 360 | 290 | 220 | 175 |
| V | 255 | 210 | 160 | 125 |
| VI | 120 | 100 | 75 | 60 |

TABLE 4-8

SULFATE CONCENTRATION OF RED RIVER, MG/L (50% OF TIME EQUALLED OR EXCEEDED)

| | Percent Control | | | |
|---|---|---|---|---|
| REACH | 0 | 30 | 60 | 90 |
| I | 1,050 | 1,000 | 900 | 900 |
| II | 725 | 680 | 680 | 600 |
| III | 550 | 545 | 520 | 490 |
| IV | 250 | 250 | 230 | 230 |
| V | 175 | 175 | 165 | 165 |
| VI | 92 | 92 | 84 | 84 |

TABLE 4-9

TOTAL DISSOLVED SOLIDS CONCENTRATION OF RED RIVER, MG/L (50% OF TIME EQUALLED OR EXCEEDED)

| | Percent Control | | | |
|---|---|---|---|---|
| REACH | 0 | 30 | 60 | 90 |
| I | 5,500 | 4,000 | 3,250 | 2,500 |
| II | 3,500 | 2,600 | 2,200 | 1,600 |
| III | 2,800 | 2,100 | 1,800 | 1,200 |
| IV | 1,000 | 850 | 750 | 680 |
| V | 815 | 715 | 625 | 540 |
| VI | 475 | 425 | 385 | 350 |

TABLE 4-10

CHLORIDE CONCENTRATION OF RED RIVER, MG/L (90% OF TIME EQUALLED OR EXCEEDED)

| | Percent Control | | | |
|---|---|---|---|---|
| REACH | 0 | 30 | 60 | 90 |
| I | 900 | 450 | 240 | 95 |
| II | 670 | 420 | 200 | 70 |
| III | 470 | 330 | 150 | 60 |
| IV | 280 | 250 | 170 | 140 |
| V | 129 | 100 | 75 | 60 |
| VI | 28 | 24 | 17 | 14 |

TABLE 4-11

SULFATE CONCENTRATION OF RED RIVER, MG/L (90% OF TIME EQUALLED OR EXCEEDED)

| | Percent Control | | | |
|---|---|---|---|---|
| REACH | 0 | 30 | 60 | 90 |
| I | 460 | 420 | 380 | 380 |
| II | 350 | 350 | 350 | 350 |
| III | 240 | 240 | 225 | 225 |
| IV | 170 | 170 | 160 | 160 |
| V | 83 | 83 | 77 | 77 |
| VI | 26 | 26 | 24 | 24 |

TABLE 4-12

TOTAL DISSOLVED SOLIDS CONCENTRATION OF RED RIVER, MG/L (90% OF TIME EQUALLED OR EXCEEDED)

| | Percent Control | | | |
|---|---|---|---|---|
| REACH | 0 | 30 | 60 | 90 |
| I | 2,400 | 1,600 | 1,100 | 850 |
| II | 1,700 | 1,300 | 950 | 800 |
| III | 1,200 | 900 | 700 | 520 |
| IV | 850 | 700 | 570 | 520 |
| V | 450 | 380 | 325 | 280 |
| VI | 175 | 155 | 140 | 120 |

4.03 Lake Texoma. Lake Texoma experiences a salt gradient or halocline. The dissolved solids concentrations appear to be the main cause of the lake's stratification. The hypolimnion is anoxic and rises to restrict most fish to water less than 10 meters deep during periods of hot, dry weather. The halocline does, therefore, have a large effect on the productivity of the lake. If the salt of the Red River (the major source of salt in Lake Texoma) were eliminated, the hypolimnion in Lake Texoma would form only during those periods of thermal stratification. The thermal hypolimnion would be shorter lived and have a greater mean depth than the dissolved solids hypolimnion. With more of the lake volume open to aerobic forms (especially to game fish species), the degree of utilization and spatial movement of fishes would increase significantly. This increased utilization may increase the carrying capacity of aquatic organisms within the lake.

4.04 Sedimentation in Lake Areas. In all areas, much of the precipitation occurs during brief but intense thunderstorms. A high rate of sheet and gully erosion results from the rapid runoff. The present average annual yield per square mile of sediment-contributing area is 1.3 acre-feet. Some additional sediment will be pumped from the subsurface cut-off systems but should be insignificant in amount. An increase in erosion rate will probably result from short-term fluctuation in the lake levels. Low lake levels will expose areas where the vegetation cover has been killed by highly-concentrated brine or removed by wave action. These areas, denuded of a vegetative cover, will be much more susceptible to raindrop impact and will allow more of the precipitation to run off thus increasing sediment transport and deposition. Additional sedimentation within the brine lakes will also result from a rise in the lake levels which will subject the steeper slopes to wave action. These effects will be especially pronounced on the lake banks where gypsiferous stringers are associated with soft shales; the combination offers little long-term resistance to erosion and subsequent slope retreat by slump. Sapping of the soft beds will remove support of the more resistant interbedded sandstone, dolomite, and gypsum beds, and lake bank slope adjustment will follow. Areas downstream from the brine lakes will benefit, however, from the sediment trapped in the impoundments. Construction of the brine lakes and their consequent trapping of stream-suspended loads will cause a reduction in the alluvial material currently being deposited in Lake Texoma.

4.05 Possible Contamination of Aquifers. If fresh water aquifers are present tnere is a possibility that some contamination of the aquifers below or downstream from the brine lakes may result from underseepage beneath the dams, lateral flow around the abutments, and rim seepage. All forms of seepage will be minimized to avoid contamination of downstream areas and associated aquifers. The proposed damsite cut-off trenches and grout curtains should decrease the water losses but construction of a collector system below each dam so that escaping brines can be returned to the lake may be necessary. If these measures prove inadequate, other remedies such as the application of a bentonite blanket may be necessary. The solution of gypsum (from stringers, lenses, and admixtures with the soft shales) in the lake areas indicates a potential loss of lake water to the subsurface. Groundwater conditions would be monitored both prior and after construction of the brine lakes as mentioned in paragraphs 6.17c and d. The probability of contamination of fresh water aquifers by escape of brines as a result of solution of gypsum is not likely to be serious because any groundwater present in the Permian rocks of the impoundment sites is already saline or of very limited extent.

4.06 Impact on Mineral Resources. The only minerals being produced in the Wichita River Basin at present are oil and gas. The oil and gas are being produced from the Bateman Ranch oil field and the Bateman Pumping Station site is within this field. Natural gas is being produced from the Juniper gas field to the east of the Lowrance Pumping Station site. No production of oil and gas has been obtained from the brine storage areas and dry holes in the area indicate that the petroleum prospects are dim. Construction of the brine lakes and low-flow dams will not, in any case, preclude production of oil and gas from these areas at some future date if these minerals are proven to be present. The only mineral being produced in the Red River Basin at present is salt. It is produced intermittently by a solar evaporation plant. The plant covers an area of about 10 acres and is reported to have an annual capacity of about 15,000 tons. The salt produced in 1969 was reported by the US Bureau of Mines to have a value of about $20,000. The project plan should have no effect on the production of salt from the area. Copper mineralization of the "red-bed" type occurs at several stratigraphic levels in a belt of Permian rocks extending from Tom Green County in west-central Texas northward through Hardeman County, Texas and into western Oklahoma. Much of the mineralization occurs as chalcocite ($Cu_2S$), and in the oxidized zones, as the copper carbonates, malachite and azurite. The chalcocite usually occurs as nodules and disseminations in shale whereas the copper carbonates characteristically are found disseminated in sandstone. The most extensive mineralization is associated with organic debris deposited in channel-scour deposits. The US Bureau of Mines core drilled one area 5 miles west of Truscott in the Wichita River Basin (Stroud and others, 1970, p 17, 19-20, 24-27) in 1968. At this locality copper minerals were exposed in a 4-foot thick zone in the Blaine Formation but the drilling program revealed that the copper mineralization did not extend far downdip from the small surface exposure. In the absence of any concrete evidence it is impossible to state that workable copper deposits exist or do not exist in the two lake areas. However, material too lean to be profitably mined today might well be profitable to mine in the future as richer orebodies are exhausted. Construction of the lake does not necessarily mean that these copper deposits will be irretrievably lost because the copper could still be recovered in the event of a national emergency, but the likelihood of its ultimate recovery will diminish as the lakes fill. Waters of the brine lakes will ultimately cover some deposits of sand, gravel, and gypsum. These materials are extensively used in the construction industry but loss of this source would be of little or no consequence for the commodities are in abundant supply elsewhere in the project areas.

4.07 Impact on Soils. Soils in the study area are variable and reflect the nature of the parent material. Much of the study area can be classified as "badlands," a land term which describes the intricately dissected terrain developed upon a base composed primarily of shales and clays. For the most part, little soil accumulates because it is quickly removed by erosion (usually sheetwash). In general, land in this category has a low agricultural productivity. Other soils associations in the area are productive, but their aereal extent is considerably less than those listed in the table. The soils range from low to high in plant nutrients but tend to have low productivity due to lack of sufficient rainfall, thinness, susceptibility to erosion, and the rough, broken terrain. Vegetation consists primarily of grasses for range grazing, but some small grains and cotton are grown. The ultimate filling of the three brine lakes will inundate and remove from potential agricultural production approximately 8,000 acres of land. In addition to this, degradation of soils not covered by lake waters is a probability if waters are withdrawn from the brine lakes for agricultural purposes. The salinity of water impounded in the lakes will vary considerably and, in times of abundant rainfall and subsequent runoff, the salinity levels may be low enough to permit use of some of the lake waters for irrigation. Tolerance of various crops to salinity levels is provided by Bernstein (1965) and Table 4-13 shows crop response to salinity. Use of these saline waters for any irrigation purpose, however, will be at the expense of the general productivity of the soil. Sodium renders soils impermeable to both air and water. Moreover, wet soils containing sodium become sticky and difficult to work. Eldridge (1960) and Bear (1964) indicate that soils are not adversely affected by salt in high concentrations if sodium is low relative to calcium and magnesium. Operational practices in such soil areas will require special management programs. These will probably include the addition of gypsum to the soils or treatment with acid to release calcium from insoluble lime.

4.08 Impact on Plant Life. Although it is evident that the proposed action will result in drastic changes in plant life, it is impossible to predict the specific changes that will occur. Based on what is known about the vegetation of saline areas and the response of plants to saline conditions (Bolen 1964, Chamman 1960, Davis 1911, Ellis 1955, Evans 1953, McMillan 1959, Miller and Egler 1950, Penfound and Hathaway 1938, Purer 1942, Rawson and Moore 1944, Wherry 1920), certain generalizations can be made. For example, it is probable that around the brine lakes there will be a zone completely devoid of vascular plants, and the vegetation beyond the edge of this area will exist in concentric floral zones. It is typical of salt marshes for these zones to be narrow and sharply defined. This is because there should be a very rapid reduction of soil salinity concentrically away from the edge of the brine lakes. Halophytes are usually poor competitors (Taylor 1939) and will become established only when the soil has become too saline for the better competing non-halophytes to survive. There are also some situations associated with natural saline areas which would not likely occur here.

TABLE 4-13

CROP RESPONSE TO SALINITY

| Salinity ($EC_e$, mmhos/cm* at 25° C) | Crop Response |
|---|---|
| 0-2 | Salinity effects mostly negligible |
| 2-4 | Yields of very sensitive crops may be restricted |
| 4-8 | Yields of many crops restricted |
| 8-16 | Only tolerant crops yield satisfactorily |
| above 16 | Only a few very tolerant crops yield satisfactorily |

* 1 mmho/cm = 640 mg/liter salt

Halophytes from localities some distance from the saline area often become established in natural salt marshes, but in brine impoundment areas the halophytic species will most likely come from the immediate vicinity. Also, the changes will certainly be too rapid for glycophytes to give rise to saline tolerant ecotypes. The exact changes in habitat, the specific communities, and especially the species composition of the communities to be expected is highly speculative. These will depend on the interaction of a number of factors. Some of the factors that come readily to mind are: type of vegetation and salt tolerances of the species already present; magnitude of water fluctuations, flooding, and silting; changes in water quality and soil chemistry resulting from drainage, erosion, and influx of fresh water; depth to the water table; amount of evaporation; environmental conditions at the time of year when plants would be becoming established (since the salt tolerance of plants is relatively low at time of germination and during early growth); and the chance presence or absence of particular species. There is one endangered plant species occurring in the project area. This is _Eriogonum correllii_, a member of the buckwheat family. This species is endemic to the Texas Panhandle and has been reported from only five localities. Only one of these localities will be affected by the project and even then it is believed that the species will be receptive to transplanting elsewhere if need be. The primary significance in preserving a species like this is that important genetic breeding factors can be preserved also. The eventual inundation with brine of the Crowell and Truscott Brine Lakes will destroy plant communities in which the following rare species are found: Andropogon scoparius var. neomexicana, Elymus canadensis, Stipa comata, Engelmannia pinnatifida, Eustoma grandiflora, Calyphus serrulatus, Atriplex confertifolia, Echinocactus texensis, Lycium berlandieri, and Bumelia lanuginosa. The other rare species listed in Tables 2-2 and 2-3 will not be affected by the project. In the Truscott Brine Lake area there are two possibilities for the Juniper Scrub Vegetation Type. Because of the lack of ground cover the red silty soils for these areas are susceptible to erosion. Wave action is likely to erode the shoreline into steep-sided, unstable banks on which plants will be unable to take hold. Consequently, saline-tolerant vegetation may not replace the present community. On those areas where some soil has accumulated a salt grass community would likely develop. The Mesquite-Grassland Savannah would probably be presented with the same set of alternatives as the Mesquite Thicket Vegetation Type. If the osmotic potential of the soil is extremely low, the areas would not be able to support any vegetation at all. This could occur initially or later as conditions change. If the osmotic potential of the water is not too low, two marsh communities may become established: a submersed soil marsh community dominated by rushes at the water's edge and an emersed soil marsh community dominated by reed grass farther inland. With decreasing osmotic potential of the water through time, these communities could be replaced by a salt grass community or perhaps by a salt cedar community. These marsh communities would not become established if the osmotic potential is too low to begin with; so that a salt grass community could directly replace the present vegetation. On the other hand, a salt cedar community could become established initially. Since the present Riparian Vegetation Type is dominated by the highly saline-tolerant salt cedar, it is unlikely that dominance would shift to another species. It is likely that salt grass would replace the nonhalophytic components of the ground cover. Drastic changes in plant life would occur, but it is impossible to predict with any accuracy what the specific changes would be.

4.09 Impact on Animal Life. Fish populations between the low-flow dams and the salt sources probably will be limited to the saline tolerant species. The low-flow dams will inhibit the entrance of fishes above the dam during low-flow periods, and high salinities will prevent the survival of species that are not tolerant. The saline-tolerant species should enjoy increased survival potential above the dams. Periods of high flow when the dams are deflated will allow fish species adapted to low salinities to move up the river thus providing some competition with the saline-tolerant species. However, those species which are not saline-tolerant probably will not survive in the rivers above the dams after the dams are inflated again. The total effect of the low-flow dams will probably not seriously change the total population ~~of the pupfish from~~ their present numbers ~~but it~~ will certainly delineate their range. Several species of bait ~~minnows thrive~~ in the saline waters above Lake Kemp. The less saline waters below the low-flow dams will almost certainly increase the range of the low saline fish species in the river above Lake Kemp. As a result some minnow populations may be reduced by competition and/or predation. The flooding of the brine lakes will eventually remove the fish in the basins involved. As the level of these lakes rises, vegetation will be progressively destroyed, and to that extent, forage and cover for land animals will be reduced. This is not expected to directly affect animal life other than fish, but it will cause displacement of these animals. Since the total area of the proposed brine storage lakes is small compared to the total regional area, the total impact on non-aquatic animal life is not expected to be very significant. As the brine lakes increase in size, it is reasonable to expect that migratory waterfowl stopping in the area will increase. Lastly, there is a remote possibility that the increase in surface area of saline water in the area might allow the establishment of mosquitoes which breed well in saline marshes in the more southern parts of Texas. The increase in surface area of water of low salinity below the low-flow dams may well increase the populations of some species of vertebrates by increasing the amount of potable water available. This factor will also increase breeding grounds for many invertebrates, some of which will serve as food for the fishes.

4.10 Land Use Changes. The proposed project will convert a total of approximately 18,900 acres of land from private to public ownership. In addition, some 1,760 acres will be needed for pipeline and pumping station installations. The pipeline acreage will be disturbed only during the construction stages. The proposed brine lakes will eventually cover a total of approximately 11,190 of the 18,900 acres converted to public ownership. Virtually all of the land concerned is presently accessible to the public on a very limited basis. Most of this land has very limited potential for farming and ranching but does provide ground cover for a limited amount of wildlife. Some potentially irrigable land now used for pasture-land and dry farming is expected to change to irrigated land. The potential irrigable land is high compared to irrigated land in the region. Increased irrigation will allow the development of higher income crops and higher yields. Double-cropping of irrigated land would be possible which would increase total crop production in the area. The streams in the areas concerned have limited fishery resources and these will not be changed significantly by implementation of the project. Approximately 11,190 acres of wildlife habitat will gradually be lost as the brine pools fill; the remaining 7,710 acres which will not be inundated can be expected to be adversely affected as a wildlife habitat if human activity (camping, boating, trail bike riding, horseback riding, and hiking) increases in these areas. This reduction of wildlife habitat on the nonflooded project lands can be minimized by establishment of wildlife management areas. For a few years moderate waterfowl populations will probably increase during the spring and fall migrations, as a result of the formation of brine lakes. As the lakes increase in salinity by evaporation, the destruction of plant life will drive away most of the waterfowl. Several relocations of negligible environmental proportions will be required by the project. These include county roads, pipelines, powerlines, and ranch structures.

4.11 Impacts of Project Purposes on Region. At present about 3,300 tons of chlorides are entering Lake Texoma each day. Removal of 45 percent of this salt (about 1,470 tons) as a result of the project will have a tremendous impact on the quality of the water in the region. Ultimately, the water in these streams and in Lake Texoma will be rendered acceptable for municipal, industrial, irrigation, and domestic purposes, 98 percent of the time. The availability of better quality water could encourage people to move into the area and also slow down migration trends out of the area. If this anticipated regional growth occurs it will likely result in adverse secondary effects. Increased development, both industrial and urban, will result in increased noise, more solid wastes, and the potential for increased water and air pollution.

4.12 It is believed that the implementation of this project will tend to serve as an incentive for increased industrial growth within the basin. In order to determine the full impact of industrial growth upon the Red River, municipal and industrial waste loads were established (Univ. of Okla., 1975). Assuming that industries will be in compliance with EPA guidelines by 1990, future waste loads from industrial discharges were calculated and combined with municipal discharges at 90, 95, and 99 percent treatment. The results of these projections indicated that for the Red River below Denison Dam, the environmental impact of industrial growth will not exceed the waste assimilative capacity (self-purification capability) of the river over the 100-year life of the project. In the upper reaches above Denison Dam, measures should be taken, such as discharge into tributaries, to reduce the impact on the river resulting from increased industrialization in the basin or else the waste assimilative capacity of the river may be exceeded in some reaches by the year 2030.

4.13 If the project stimulates growth throughout the basin, there will be adverse secondary impacts on fish and wildlife production. Measures must be taken by the responsible parties to minimize such impacts. Although terrestrial and aquatic habitat will undoubtedly be destroyed or diminished in many places, if the developers comply with existing State and Federal laws concerning pollution control, then adverse environmental effects should be minimal.

4.14 Downstream effects will also ~~mean improved~~ fishing because of improved water quality and will directly affect the project area because this is a ~~frequently visited~~ fishing site for area residents. Some fish habitat improvements are expected due to improved water quality below the low-flow dams, but this will be offset by dry conditions and reduced flow in the reaches directly below the damsites. Domestic and wildlife habitat would be improved because of the better quality water downstream from the low-flow dams. Greenbelt areas could be created adjacent to the streams in the downstream reaches and these areas would become more aesthetically pleasing because of the survival of more species of plants.

4.15 Recreational - New Water Area. The proposed chloride control project would provide a slowly expanding water area in a water-short region. However, the salinity of this water and the expected fluctuations of lake levels will restrict the usefulness of the water for recreation purposes. In all, about 11,190 acres will eventually be inundated with brine. The water level behind the low-flow dams is expected to fluctuate widely and will be of limited value for boating and swimming due to this fluctuation. Value is also limited by the small acreage projected. The largest brine pool behind a low-flow dam will be 14 acres and these pools are expected to be drawn down much of the time by removal of the brine to the evaporation lakes. Yet, due to the lack of alternative sites these may be important to people within a wide radius. The larger evaporation lakes can be expected to expand slowly to a size adequate for boating and water skiing in addition to swimming and water play. Any facilities constructed for recreation use may be located above the maximum brine pool associated with the low-flow dams, however, in the early years of the project, facilities above the brine pool can be hundreds of yards from the water's edge. Temporary or portable facilities must be envisioned in this case. Fishing potential is limited and must be assumed to be insignificant in the long run. The length of time fishing could be possible is uncertain because it is not known at what rate the brine lake will progress toward salt concentrations above the tolerance of fish life. The proximity of the proposed brine evaporation lake number VII to the new Copper Breaks State Park makes possible coordinated recreational development by the Texas Parks and Wildlife Department. The new park on the northside of the Pease River will contain 80-100 picnic sites, 30-40 campsites, and a freshwater lake in addition to other facilities. The lake will provide some fishing and water sports, but will be too small to allow water skiing. The large brine pool across the river could fill this latter demand and require only temporary or movable sanitary facilities at this site.

4.16 Public Access to Recreation Space. In all, over 26 square miles of the project area will pass into public ownership and thus become potentially available for public access. Although one might assume that a surplus of outdoor recreation space might exist because of the long-extended population decline, this is not the case because practically all of the land is privately owned and few of the landowners welcome recreationists. A recent report by the Nortex Regional Planning Commission states:

> "The major problem of this great amount of open land is its being unavailable to people of the area for leisure, as in the case of rural agricultural or ranching land, or not being of sufficient size in the rural urban centers for realistic use. Therefore, even though open space per se abounds, it offers few benefits to area citizens other than visual."

In short, accessible open space appears to be one of the major shortages in the four-county area. Access for a range of outdoor activities may be easy for those whose relatives or friends are landowners, but for those without these personal connections there is "no place to go." A major recreational impact of the chloride control project will be in providing three large blocks of accessible open space in this area of Texas and Oklahoma. Roads required in the construction and maintenance of the project will give public access to these new open areas. In the early years of the project the lands above the brine pool could provide new public bird hunting acreage, although this will diminish as the brine pool expands. The potential exists for public campsites and picnic areas offering pleasing views of rolling brush and grassland broken by stream escarpment and largely devoid of manmade features. In many aspects these views offer the epitome of the western ranch country landscape. Hiking trails and riding paths could also be developed here, and space might be conveniently found for motorcycles and off-trail vehicles, especially on the brine flats during low water periods.

4.17 Impact on Historical and Archeological Sites. There are no significant historical sites within the proposed project area. The paleontology of the general region including the project area has been rather thoroughly investigated and is now fairly well established. A recent survey of the project sites resulted in sparse findings and it is highly unlikely that any significant paleontological information will be lost as a result of the proposed project. One exception to this generalization concerns the dark gray clays lying beneath the buff to brown alluvium in the high cut banks along the Middle Fork of the Wichita River. These will be watched closely during the excavation for the Lowrence low-flow dam and pumping station in anticipation of finding possible skeletal or other remains of prehistoric bison. Archeological exploration of the region including the project sites has been very limited. The recent brief exploration of the actual project sites indicates the presence of several potentially important archeological sites which warrant further investigation and possible salvage prior to implementation of the project. An intensive archeological survey, for locating additional sites and testing and evaluation, is currently being developed with implementation scheduled for early in 1976.

4.18 Impact on Air Quality. In the Red River Basin area, air pollution is currently not a significant problem in the environment. The characteristic winds of the plains area and the atmospheric condition prevalent in the area purge the basin of contaminants which if present in sufficient concentrations could result in air pollution. The few industries located along the Red River and its tributaries contribute no adverse environmental air pollution episodes throughout the basin. The type of industry that locates in the basin will determine the resulting air pollution in the future. The existing industries in the basin are required to meet national ambient air standards or the individual state standards. These standards will surely increase in stringency as the available technology improves both in industrial methods and pollution abatement techniques. The potential for urban air pollution because of the meterological conditions existing in the Red River Basin (Texas through Louisiana) is insignificant. The basin is situated in an area in the United States where no ambient air pollution affects the area. This has been the case in the past, and should continue for the future if new industry adheres to the state and national ambient air standards.

4.19 Impact on Aesthetics. Most of the stream areas that will be altered upstream from Lake Texoma are natural, untouched landscapes. The construction of project facilities such as dams, pipelines, and pumping facilities may be regarded by some as an encroachment upon the natural landscape. In addition, the construction of facilities will disturb over 300 acres of land with the bared surface subject to accelerated erosion until it becomes revegetated. Fluctuation of the brine lakes will produce bare salt encrusted shorelines from time to time. The aesthetics of the areas below the chloride control structures should be improved because of better quality water resulting in the potential for a higher diversity of plant and animal life to occur in the rivers and adjacent lands. The improved water quality should allow the potential for more recreational opportunities to occur downstream. Greenbelt areas could be developed along the reaches of improved water quality and other types of scenic areas could be developed.

4.20 Operation and Maintenance Requirements. Maintenance procedures will necessitate the construction of a central maintenance and administration building. All O&M personnel will be officed here and it will be the storage place for project trucks, a boat, spare pumps, and other repair parts. O&M personnel will be responsible for maintenance on service roads, collection systems, pumps, pipelines, and brine lake dams. They will also maintain the minimum health facilities and dispose of wastes. The Tulsa District O&M personnel will set up a groundwater monitoring system around the brine lakes. They will start on a once-a-month basis which can be altered as monitoring experience dictates. It is possible that there could be a different schedule for each brine lake. The USGS will be responsible for a monthly water quality check on two source areas, XIII and XIV.

4.21 Impact on the Economy and Social Conditions. Social and economic impacts of the proposed project will vary throughout the region. In the seven county area where construction will occur, impacts will be more immediate and temporary. Little long-term community growth is expected though short-term growth due to an influx of construction workers is expected. Out-migration of young people for employment purposes is a long established trend. Long-term employment opportunities are not expected to increase in the area. The lack of raw materials, labor force, markets, and transportation facilities, necessities for industrial development, will not be changed by the project. Short term employment will be enhanced due to project construction. Construction will inject new money into local economics which should generate an increase in business activity. Property values are not expected to increase significantly in the immediate vicinity of the project.

4.22 Effects downstream of the proposed project in a 35-county area will be long term in nature. Intensification of agricultural production on irrigated land would not necessarily support an increased farm population because of technological advances in farm mechanization. As a result of the project, the industrial centers within the region may experience alteration. In-migration of skilled people from other areas as well as rural-to-urban migration is expected to occur, resulting in some disruption of community cohesion. Employment in both industry and agriculture will increase and then stabilize over time, with industrial employment increasing at a faster rate. White collar occupations in industry should increase faster than blue collar occupations. Per capita income is likewise expected to increase as the economy expands, resulting in favorable impacts on other community institutions such as educational facilities, recreation facilities, and public services. Use of improved quality water from the Red River and Lake Texoma by surrounding municipalities relying on the Red River as their source of water should decrease treatment costs and allow additional money for other public services.

## SECTION 5

### ANY PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSAL BE IMPLEMENTED

5.01 Plants. The inundation of lands by the Crowell, Truscott and Fish Creek Brine Lakes will kill vegetation within the normal pools and only salt-tolerant species will survive in the immediate area surrounding the lakes. The rare and endangered species of plants are listed in Table 2-2 and 2-3, Section 2. As shown in that table, the eventual inundation with brine of the proposed lake areas will kill individuals of certain of these species.

5.02 Production of Range Lands. The change of land ownership from private to public will take some range land out of production. The inundation with brine will progressively result in an irreversible loss of the flooded land. Table 5-1 below gives some estimates of the losses of herbage that can be expected due to the proposed action. These values were calculated from the data given in this report on the area of each vegetation type and the probable herbage production of each type. As shown in the table, there will be about 12,487,600 pounds of herbage production per year that will be lost. These values do not include the herbage production of the Woodland and Juniper Scrub Vegetation Types. There are some localized grass stands within the Woodland Vegetation Type, but the Juniper Scrub Type has very little, if any, grazing value. Most of the areas that will be flooded, at least initially, are not highly productive in their present state.

5.03 Wildlife Habitat. The habitat areas to be lost first are those along the major streams. The vegetation of these areas provides food and cover for squirrels, rabbits, coyotes, quail, doves, and songbirds. The displacement of wildlife from these areas onto adjacent escarpments and uplands will place additional pressure on those food and cover resources to the point of their being over-utilized, thereby resulting in increased deterioration of the habitat and eventual loss of the wildlife. With further flooding there will be a further loss of wildlife habitat and a further displacement of animals. The Woodland Vegetation Type (about 3,420 acres) at the Crowell Brine Lake site and the Juniper Scrub Vegetation Type (about 2,110 acres) at the Truscott Brine Lake site would generally be the last to be inundated by brine.

5.04 Animals. The adverse environmental effects on animal life which cannot be avoided should the project be implemented is considered minimal. Some low quality livestock grazing land will be lost, but the number of cattle which can be supported by the land in question is small compared to the total livestock population of the four county area encompassing the project sites. Slightly more than one-half of the area of the project sites which now provide food and cover for wildlife will be lost and the remainder of the project area will become less efficient as wildlife habitat if human recreational activity increases in those areas. Development of effective wildlife management in these areas can minimize the loss. Approximately

TABLE 5-1

ESTIMATES OF FUTURE LOSSES OF HERBAGE DUE TO THE PROPOSED ACTION AT THE CROWELL AND TRUSCOTT BRINE LAKES, TEXAS. VALUES ARE IN TOTAL POUNDS OF HERBAGE PER YEAR

| Vegetation Type | Loss |
|---|---|
| Mixed Shrub Savannah | 2,438,400 |
| Upland Grassland | 1,774,000 |
| Bottomland Grassland | 3,934,200 |
| Mesquite-Grassland Savannah | 4,038,000 |
| Mesquite Thicket | 303,000 |
| Total | 12,487,600 |

30 miles of natural low quality streams will be inundated by the manmade lakes and this will destroy a small amount of freshwater fishery. Some loss of saline-tolerant minnows and pupfish will occur in the streams below the low-flow dams. Provided that the brine pools at the low-flow damsites result in some increase of brine volume between the salt sources and the dams, the survival of the salt-tolerant fishes may be enhanced sufficiently to at least partially balance the loss of these species below the low-flow dams.

5.05 Recreational and Aesthetic Values. Recreation resources presently available to the public will be only indirectly affected by the project. Sites for the lakes and facilities lie on land which is privately owned. Only one public road presently crosses a proposed impoundment site, (low-flow dam number VII, in southeast Cottle County), which presently contains no recreational development. In addition, the construction of the pipelines will disturb nearly 300 acres with the bared surface subject to accelerated erosion until revegetated. The potential for pipeline breaks or leakage which could threaten additional acreages with soil and vegetation damage from brine spills also exists. Although dams, pipelines, and pumping stations of modern design are not offensive as such, they may be regarded by some as an encroachment upon a wildlife landscape where at present the only manmade features within a full horizon view might be a dirt road, a fence, or a windmill. Most of the stream areas to be altered have pleasing aspects as natural, untouched landscapes. An exception would be the Bateman pumping station site (Area VIII) where a small oil field exists along the stream with the usual array of pumpjacks, service roads, storage tanks, and pipelines. The aesthetic conditions surrounding the brine pools also raise some question. Fluctuations of the low-flow pools should produce bare salt encrusted slopes from water level to high pool line. Likewise, the margins of the evaporation lakes may provide unattractive vistas during periods of rapid evaporation, or unpleasant conditions due to blowing dust, sand, and salt under the same conditions. Should a steady rise occur, the evaporation ponds will be surrounded for many years by a steadily advancing ring of drowned and salt-scaled brush. Some archeological sites may be destroyed if they are not salvaged. In addition to the above, there will be some adverse effect on minor oil production, and some county roads and utilities will require relocation.

5.06 Water Losses. The removal of brine from behind the low-flow dams will produce dryer conditions for some distance downstream with resultant habitat changes. About 7% of the annual flow of the Wichita River entering Lake Kemp will be lost through brine evaporation. Each one of the brine lakes will reduce the downstream flow by 3.5 c.f.s. or 2500 acre-feet per year. Also, an estimate of 30 miles ~~of natural~~ stream course will be lost due to inundation or other modification by the project. These streams are intermittent in flow and are in some places remote from public view at present, but they are valued as natural untouched landscapes.

5.07 Public Use. Public visitation to the project sites and the expected use of the lake areas will produce certain adverse impacts which can be, at least in part, mitigated by the provision of public service facilities and by the supervision of visitor activities. Soils of this area are highly susceptible to wind and water erosion when vegetation is disturbed. Areas of fragile soil and vegetation may therefore require protection from heavy impact by restricting off-trail vehicles to the less fragile areas and by providing paved roads, paths, and overlooks at heavy traffic sites. Besides erosion and vegetative damage, public use would increase the level of noise in the area and the possibility of man-caused range fires.

5.08 Land Owners' Concerns. Concerns of local landowners center around the question of contamination of presently potable water supplies through seepage from impoundments or leakage from pipelines. Additional questions are raised by the expected greater public access to project sites lying within or adjacent to extensive farming or ranching units. Inconvenience due to traffic, noise, and litter is expected along with greater problems of trespassing, unauthorized hunting, vandalism, and theft. Range fires resulting from increased activity in the area are also a major concern during the dry season of the year.

5.09 Approximately 70 land ownerships will be affected by the project. The most recent figures show that 18,900 acres of land will be converted from private ownership to public ownership by fee and 1,760 acres will be bought in easement.

SECTION 6
ALTERNATIVES TO THE PROPOSED ACTION
(AREAS VII, VIII, AND X)

Alternatives Studied before Project Authorization

6.01 Under authority of the Federal Water Pollution Control Act, Public Law 660 (84th Congress), Public Health Service began a report of the Arkansas and Red River Basins natural chloride pollution in July 1957. That report, "Water Quality Conservation, Arkansas-Red River Basins," June 1964, reported the need to control 15 natural chloride source areas in the Arkansas-Red River Basins. The Corps of Engineers findings were presented in a two-part survey report in response to a 16 December 1959 study authorization that read:

> "Resolved By The Committee On Public Works Of The United States Senate, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the report of the Chief of Engineers on the Arkansas River and tributaries, Kansas, Oklahoma, and Arkansas, published as House Document No. 308, Seventy-fourth Congress, and the report on the Red River and tributaries, Arkansas, Louisiana, Oklahoma, and Texas, published as House Document numbered 378, Seventy-fourth Congress, and other pertinent reports, with a view to determining in Cooperation with the Division of Water Supply and Pollution Control, Public Health Service, methods and means of improving and managing water quality in the Arkansas and Red River Basins."

The Part I, survey report, printed as Senate Document No. 110, dated October 1966, recommended a control plan for Areas VII, VIII, and X in the Wichita River Basin. The Part II, survey report, submitted 20 May 1966, recommended a control plan for five of the remaining six salt source areas in the Red River Basin and four of the five salt source areas in the Arkansas River Basin.

6.02 Project Document Plan. The authorizing document, Senate Document 110, 89th Congress, 2d Session, recommended construction of a single-purpose water quality control plan for the Wichita River. The approved control plan as discussed in subparagraph 9c, Volume 1, Senate Document 110, and authorized by the Congress was to control natural chloride pollution. The project included three low-flow dams, one on each fork of the upper Wichita River, two brine storage lakes, and pumping plants and pipelines to convey the brine from the low-flow brine collection sites to the brine storage lakes. The pumping facility at each low-flow dam consisted of two 9,000 gpm pumps and a 36-inch-diameter pipeline to convey the brine to a brine storage lake. The brine storage lakes were designed to impound runoff from a 100-year-storm occurring after 100 years' accumulation of brine and sediment. The storage allocation for the Area VII brine storage lake was 173,000 acre-feet and for Areas VIII and X was 160,000 acre-feet. It was estimated that the plan would control 80 percent of the natural salt contribution in the upper Wichita River Basin above Lake Kemp. This would reduce the chloride concentration in Lake Kemp to an acceptable level of about 200 mg per liter 98 percent of the time. The first cost of the project was $46,400,000 with annual charges of $1,855,000, all to be borne by the Federal Government. The States of Texas, Oklahoma, and Kansas advocated full Federal responsibility for measures to control natural salt pollution and advocated that non-Federal interests should be completely responsible for programs to control manmade brine pollution. A map of the control plan is shown in Appendix I.

Other alternative studies made during development of the project document plan included the following control plans:

6.03 <u>Desalination</u>. Desalting plants were among the new technical and improved processes for increasing the usefulness of a poor quality water resource. Desalination was not the best solution to the basin water quality problem. The cost of producing water by desalination at that time, exclusive of collection and disposal costs, was about $1.00 per 1,000 gallons. The cost of controlling the chlorides by other alternatives was far less costly as collection and plant effluent disposal facilities would be required in addition to the desalting plant.

6.04 <u>Creating Brine Disposal Cavities by Nuclear Explosion</u>. The Tulsa District, in August 1963, requested the Nuclear Cratering Group (NCG) to advise whether advances in nuclear technology warranted a reappraisal of applying nuclear excavation techniques to certain alternative chloride control methods. The NCG replied that of the many proposed concepts for utilizing nuclear explosives in construction, two methods appeared to hold the greatest potential for eventual application to brine disposal storage. They were: (1) injection into subsurface strata through a cavity created by controlled nuclear detonation and (2) impoundment behind created landslide dams. The NCG concluded in December 1963 that although some progress has been made in the technology since 1960, there had been no experiments specifically designed to investigate the problems of brine disposal or storage during that period. The NCG therefore recommended that, although nuclear explorations had some potential application to this field, they did not warrant further study for brine disposal.

6.05 <u>Subsurface Injection</u>. In November 1959, the University of Oklahoma, under contract to the Public Health Service, initiated a study to determine the economic and technical feasibility of deep subsurface disposal of natural and manmade brines as a part of the Arkansas-Red River Basins water quality conservation project. Studies were conducted on the potentials of underground formations serving as brine disposal reservoirs. Conclusions reached by the University of Oklahoma report entitled, "Deep Subsurface Disposal of Natural and Manmade Brines in the Arkansas and Red River Basins," August 1960 were as follows:

a. Disposal of oil field brines and other industrial wastes by injection into deep subsurface strata had become common practice.

b. For this method to be successful, the strata for injection must be permeable.

c. Injection must be accomplished in geologic formations which would prevent the surface or near surface reemergence of the injected pollutant.

d. During the life of an injection well, its capacity frequently decreases and several methods to restore the capacity of a well had been developed.

Treatments included high pressure injection, introduction of acid or chloride, and sand fracing. Brine injection costs ranged from $415 to $550 per million gallons for the various study areas, excluding the cost of collection.

6.06 The James A. Lewis Engineering Company of Dallas, also under contract to the Public Health Service, investigated the potential for disposal of natural brines in deep formations in the upper Red River Basin. The scope of investigations focused mainly on the Arbuckle (or Ellenberger) formation which has shown a high capacity for economical assimilation of waste in Kansas and northern Oklahoma. Conclusions reached were that injection held promise for some areas but large scale field testing and investigation would be required to firm up preliminary data.

6.07 Based on conclusions from the University of Oklahoma and the Lewis reports, the Tulsa District performed office studies to appraise subsurface injection as a possible solution to disposal of the natural brines. Results of cost studies showed subsurface injection to be more costly than surface impoundment reservoirs. Also, subsurface injection would not be practical until a large scale subsurface investigation program could be completed to assure technical feasibility.

6.08 Pipeline to the Gulf of Mexico. An obvious alternative to local disposal that was considered involved basin exportation of the concentrated brine to the Gulf of Mexico. In addition to large pumping facilities, the plan would require an extensive pipeline to the Gulf. Cost studies showed that the plan would be several times more costly than alternatives consisting of a plan of local disposal.

6.09 Other Alternatives. Other potential solutions included: (1) complete impoundment immediately below the source area. All flows up to and including the storm whose recurrent interval is equal to or greater than the project life would be impounded; (2) diversion of fresh water around a salt source area; (3) dilution by supplementing stream flow with fresh water; and (4) the application of hydrostatic head to suppress the flow from brine springs. Results of these studies showed a poor outlook for success.

6.10 Postauthorization Studies Since Passage of National Environmental Policy Act. Postauthorization studies, encompassing reformulation and redesign of the project document plan, have resulted in reaffirmation of the authorizing document project purpose and refinements in the proposed plan of improvement.

6.11 Development of the GDM Recommended Plan. The project purpose of natural chloride control with the goal of reducing the natural chloride content of water flowing into Lake Kemp to meet acceptable standards for municipal and industrial water supply and irrigation was reexamined and was reaffirmed to be still valid in that streamflow records continue to show large quantities of natural chloride pollution. Also, with development of control measures for the remaining natural salt source areas (Area VI, Area IX, Areas XIII and XIV, and Area XV) and non-Federal interest control of manmade brines, the quality of the water resource of the Red River will be improved. An additional goal which is also valid is to attain an optimum level of control with a minimum reduction of normal flows into Lake Kemp. Studies of the environmental impact of the proposed action were included in the parameters to guide project formulation. These studies would consider inclusively the beneficial impacts resulting from water quality improvement and the potentially adverse impacts of the proposed action to achieve the project goal.

a. Method of Control. Details of the studies of alternative methods of controlling natural chloride pollution and the no action alternative are contained in the paragraph entitled "Alternatives" of this section. The best plan remains basically as proposed in the project document which is collection at or near the source and disposal by storage and evaporation in brine lakes.

b. Degree of Control. A computer program was developed for hypothetical stream pumping operations to determine the scale of structural requirements and the water quality effects of various degrees of control. This program was run for various maximum pump rates at various hypothetical pumping station locations for the period of streamflow record. For each predetermined pump rate, the program computed the daily flow and chloride load that would have been pumped from the stream and the amount of flow and load that remainded and passed downstream.

In addition to these determinations, different combinations of pumping rates were considered to establish brine lake storage requirements for a range of degrees of chloride control. As the approximate scale of development for a certain degree of control was known, costs and excess of economic outputs over project costs were developed for that control plan. As a result of these investigations, the 80-percent degree of control was selected because:

(1) This will reduce chloride concentration in Lake Kemp water to the point where it will meet public health standards.

(2) The economic outputs are greater than the costs.

(3) The degree of control attainable at the remaining natural source areas in the comprehensive Arkansas-Red River control plan is not definitely known; therefore, the degree of control in this project should be as high as feasible since control of other natural source areas may prove to be more difficult and costly.

(4) Streamflow depletion and project costs and the scale of development increase sharply for increments of control above 80 percent.

c. Economic Balance. Having determined the method of control to be employed, i.e., collection at or near the source and pumping to a brine storage lake, and the degree of control to be accomplished, i.e., 80 percent, the most economical balance of removal from the source areas was determined. The estimated average natural chloride load from Area VII is 186 tons per day; from Area VIII, 170 tons per day; from the reach between Bateman and Ross Station, 25 tons per day; from Area X, 48 tons per day; and from the area between these source areas and Lake Kemp there is an additional 24 tons per day, making a total of about 450 tons per day entering Lake Kemp. Therefore, in order to control 80 percent of the natural chlorides entering Lake Kemp, an average load of about 360 tons per day must be removed from the project source Areas VII, VIII, and X. Several combinations of amounts of natural chloride to be removed were selected and they were plotted against preliminary cost estimates for each combination. The average rate of water pumped for each combination of natural chloride removal was also considered. The development which removes 158 tons per day from Area VII and 204 tons per day from Areas VIII and X was selected as the proposed plan since it is the least costly plan, requires the least pumping, and reduces the normal inflow into Lake Kemp the least.

d. Refinements. After the preliminary control plan was developed by the applied project formulation procedures, it was refined to obtain the best plan and is presented as the proposed project plan of development.

6.12 Departures from Project Document Plan. Table 6-1 shows a comparison of pertinent data for the project document plan and the proposed plan. Major departures are as follows:

a. Resiting of Damsites.

(1) Brine Dam VIII and X (Truscott Brine Lake). The dam was resited about one-half mile upstream to provide the least costly location for the embankment and to reduce the amount of fresh water impounded. The project document site would impound runoff from both Bluff and Buffalo Creek Basins. The proposed site would impound runoff in the Bluff Creek Basin only.

(2) Low-Flow Dam VII (Y-Ranch Pumping Station). The pumping station was resited about four miles upstream to provide the least costly brine collection and pumping plan.

(3) Low-Flow Dam VIII (Bateman Pumping Station). The pumping station was resited about 14 miles upstream to provide the least costly brine collection and pumping plan and to reduce the amount of fresh water surface runoff that would mix with the highly concentrated brine.

(4) Ross Pumping Station. This facility was added to the project plan to collect and pump the intervening load contributed along the South Fork Wichita River between the Bateman and Ross Pumping Stations and would be located about 2 miles upstream from the project document Area VIII site. This facility would be staged for construction after the Bateman Pumping Station had been in operation during the early years of project life and observation of brine flows at the site showed that construction was necessary.

(5) Low-Flow Dam X (Lowrance Pumping Station). The pumping station was resited about 17 miles upstream to provide the least costly brine collection and pumping plan and to reduce the amount of fresh water surface runoff that would mix with the highly concentrated brine.

b. Elimination of Outlet Works. The project document plan included an outlet works in each of the brine dams. The outlet works consisted of a 36-inch-diameter concrete conduit, tower, and personnel bridge. Reasons for elimination of this facility from the proposed plan are listed below:

(1) Releases from the highly concentrated brine impoundments would create adverse effects along the downstream reaches of the Wichita River and in Lake Kemp thereby defeating the purpose of the project.

(2) Inclusion of an outlet facility at each brine storage dam with the capability of emptying the lake in about one month would increase the project cost by about $3,000,000. This expenditure would not insure that a pending embankment failure could be avoided. Case histories of the more prominent embankment failures show that little warning time precedes the catastrophic event.

TABLE 6-1

PERTINENT DATA
PROJECT DOCUMENT PLAN VS. RECOMMENDED PLAN

WICHITA RIVER PLAN

| Item | Document Plan | Recommended Plan | Document Plan | Recommended Plan | | Document Plan | Recommended Plan |
|---|---|---|---|---|---|---|---|
| | | "Y" Ranch | | Bateman | Ross | | Lowrance |
| | Low Flow VII | Pumping Station | Low Flow VIII | Pumping Station | Pumping Station | Low Flow X | Pumping Station |
| **GENERAL** | | | | | | | |
| Area | VII | VII | VIII | VIII | VIII | X | X |
| Stream | North Fork Wichita River | North Fork Wichita River | South Fork Wichita River | South Fork Wichita River | South Fork Wichita River | Middle Fork Wichita River | Middle Fork Wichita River |
| River mile | 209.0 | 213.0 | 60.8 | 74.9 | 61.5 | 3.1 | 20.5 |
| Drainage area, sq mi | 489.0 | 492.0 | 440.1 | 221.0 | 396.0 | 160.7 | 60.4 |
| **ELEVATION, FEET, msl** | | | | | | | |
| Top of dam | 1560.0 | - | 1483.0 | - | - | 1500.0 | - |
| Maximum pool | 1557.0 | - | 1480.0 | - | - | 1497.0 | - |
| Top of deflatable weir | 1549.0 | 1539.0 | 1474.0 | 1594.5 | 1463.0 | 1483.0 | 1570.0 |
| Top of 100-year conservation pool | - | - | 1474.0 | - | - | 1483.0 | - |
| Streambed at damsite | 1522.0 | 1534.0 | 1450.0 | 1589.5 | 1458.0 | 1459.3 | 1565.0 |
| **STORAGE, ACRE-FEET** | | | | | | | |
| Maximum pool | 7,400 | - | 5,320 | - | - | 4,035 | - |
| Top of deflatable weir | 3,200 | 22 | 2,820 | 20 | 6 | 620 | 10 |
| **SPILLWAY** | | | | | | | |
| Location | Valley | Valley | Valley | Valley | Valley | Valley | Valley |
| Type | Ogee | Deflating | Ogee | Deflating | Deflating | Ogee | Deflating |
| Length of crest, feet | 294 | 80 base | 287 | 40 base | 90 base | 182 | 30 base |
| Crest elevation, feet, msl | 1537.0 | - | 1460.0 | - | - | 1477.0 | - |
| **PUMPING PLANTS AND PIPELINES** | | | | | | | |
| Pumps | | | | | | | |
| Number and size (gpm) | Two - 9,000 | One - 9,000<br>One - 3,800 | Two - 9,000 | One - 6,750<br>One - 2,250 | - | Two - 9,000 | One - 4,500<br>One - 1,800 |
| Maximum pumping rate, gpm | 9,000 | 9,000 | 9,000 | 6,750 | 4,500 | 9,000 | 4,500 |
| Average pumping rate, gpm | - | 3,690 | - | 2,340 | 765 | - | 1,890 |
| Entrance invert elevation, feet, msl | 1537.0 | 1535.0 | 1460.0 | 1593.0 | 1459.0 | 1477.0 | 1566.0 |
| Pipelines | | | | | | | |
| Number and size | One 36" | One 33" | One 36" | One 30" and 36" | One 24" | One 36" | One 30" |
| **CHLORIDES** | | | | | | | |
| Natural, average tons/day | 207 | 186 | 233 | 170 | 195 | 75.5 | 48 |
| Removed, average tons/day | 192 | 158 | 197 | 142 | 21 | 70 | 41 |
| **AREA, ACRES** | | | | | | | |
| Maximum pool | 710 | | 600 | - | - | 500 | - |
| Top of deflatable weir | 360 | 14 | 340 | 12 | 4 | 80 | 6 |

TABLE 6-1 (CONT)

| Item | Document Plan | Recommended Plan Crowell Brine Lake | | Document Plan | Recommended Plan |
|---|---|---|---|---|---|
| | Brine Dam VII | Initial | Ultimate (2) | Brine Dam VIII and X | Truscott Brine Lake |
| **GENERAL** | | | | | |
| Area | VII | VII | VII and IX | VIII and X | VIII and X |
| Stream | Canal Creek | Canal Creek | Canal Creek | Small tributary to North Fork Wichita River, appx 3 miles northwest of Truscott, Texas | Bluff Creek |
| River mile | - | - | 1.6 | - | 3.6 |
| Drainage area, sq mi | 46.1 | - | 46.0 | 29.2 | 26.2 |
| **ELEVATION, FEET, msl** | | | | | |
| Top of dam | 1487.0 | 1457.0 | 1482.5 | 1510.0 | 1509.5 |
| Maximum pool | 1481.4 | 1452.4 | 1477.7 | 1505.0 | 1505.2 |
| Top of conservation pool | (1)1470.0 | 1438.0 | 1471.0 | (1)1498.5 | 1499.0 |
| Streambed at damsite | - | 1351.0 | 1351.0 | 1370.0 | 1408.0 |
| **STORAGE, ACRE-FEET** | | | | | |
| Spillway crest | 173,000 | 88,540 | 210,200 | 160,000 | 116,200 |
| **SPILLWAY** | | | | | |
| Location | Saddle | Saddle | Saddle | Saddle | Saddle |
| Type | Uncontrolled | Uncontrolled | Uncontrolled | Uncontrolled | Uncontrolled |
| Length of crest, feet | 100 | 100 | 1,000 | 100 | 1,000 |
| Crest elevation, feet, msl | 1470.0 | 1446.5 | 1474.0 | 1498.5 | 1502.0 |
| **OUTLET WORKS** | One 36" pipe | - | - | One 36" pipe | - |
| **AREA, ACRES** | | | | | |
| Spillway crest | - | 3,331 | 5,490 | - | 3,090 |
| Top of conservation pool | 4,940 | 2,676 | 5,260 | 5,750 | 2,980 |

(1) 100-year event occurring after 100 years' accumulation of brine and sediment.

(2) This plan has been revised to include Areas XIII-XIV & XV. See table in paragraph 6.48c.

(3) Assurance that the conduit gates would function properly when subjected to a highly concentrated brine environment is questionable. Therefore, the facility might not operate satisfactorily in an emergency situation.

(4) Unlike many multipurpose projects, the brine lake inflow could be regulated. Since the largest volume of lake storage would be pumped brine, the pumping operation could be discontinued if and when an emergency occurred.

6.13 Brine Lake Spillway Design. The spillway levels were set by adding the flood volume of the 100-year flood to the top of the conservation pool. The probable maximum floods were routed through the reservoirs starting at the spillway crest to determine maximum pool elevations to which freeboard was added for the top of dam.

6.14 Alternatives. This discussion of alternative control methods that follows is based on a scale of development to control 80 percent of the chloride load emanating from headwaters of the basin. The process of determining the economic balance is outlined in paragraph 6.11.

6.15 Plan A. Collection and Off-Stream Brine Storage.

a. Collection. Hydrologic studies show that desirable control can be attained by intercepting and pumping the highly concentrated base brine flows immediately below the source areas. The proposed interception facility would consist of a deflatable low weir dam to impound a minimum pool for pumping. This facility would hold a low percentage of the total flows but would remove by pumping a high percentage of the chloride pollution. This plan is especially favorable for control at the upper Wichita River because (1) streamflow records show that flood flows carry the major volume of annual runoff; and, (2) these floods occur only a small percentage of the time.

b. Disposal. The project area is ideally suited for brine disposal by solar evaporation. The region of north central Texas has an average rainfall of about 21 inches per year and an average lake evaporation rate (unadjusted for chloride concentration) of about 65 inches per year. Early investigations for site selection of the brine lakes considered locations that would be close to the interception and pumping facilities. This plan would have obviously minimized both initial and operational pump facilities costs. Preliminary geological investigations in the vicinity of source Area VIII showed the adjacent uplands to be located in the Dog Creek shale, a formation consisting of three dolomite and gypsum units separated by shale intervals of about 20 feet. In absence of specific stratigraphic control in this area, the geology was projected from known points near the source area. Extensive solution activity in the dolomites and gypsums, particularly in the Blaine formation immediately below the Dog Creek shale, is common in the area causing cave formations, collapse structures and sinks. Known solution and collapse activity with surface expression in the form of numerous sinks occur within a few thousand feet of Spring Number 4 at the source area. The generally adverse foundation characteristics inhibited technical feasibility and the plan for local brine storage was discarded. Upon completion of an extensive site selection study, the following off-stream brine storage sites were selected.

c. Truscott Brine Lake. The brine lake would be located on Bluff Creek, a south bank tributary of the North Fork Wichita River. The proposed embankment has been sited so as to effect complete impoundment in the Choza shale that is considered to be relatively impervious. Known seeps of relatively good water quality, emitting from the San Angelo in the upper reaches above the maximum pool, would not be adversely affected by the brine impoundment. A positive cutoff trench and grouting beneath the embankment and extending along each abutment would minimize underseepage. A ground water monitoring system would be provided for early detection of any changes in the local ground water systems that could be related to the brine impoundment.

d. Crowell Brine Lake. The lake would be located on Canal Creek, a south bank tributary of the Pease River. Most of the reservoir area would be in the San Angelo formation that is predominantly sandstone. Extensive rim problems and treatment in this formation are not anticipated. However, removal and special treatment of gypsums in the left abutment and between stations 160+00 and 180+00 along the axis of dam would be required. A cutoff trench would be constructed beneath the entire length of the embankment. Cutoff trench excavation would allow the foundation to be inspected and treated for gypsum joints or other adverse conditions if encountered. A grout curtain would be placed the full length of the cutoff trench. In addition, an areal seepage and ground water monitoring system would be developed. Estimated first cost and annual charges, as shown in Table 6-2, are $42,100,000 and $2,000,000.

6.16 Plan B. Collection and Off-stream Evaporation Pond Disposal.

a. Collection. The method of collection and the rate of pumping would be the same as Plan A.

b. Disposal. Brine storage and disposal would be accomplished by constructing evaporation ponds in the Bluff Creek and Canal Creek Basins. The selected locations would be in the vicinity of the project document sites for the brine lakes. About 5,560 ponded surface acres would be required for disposal of an average 19.3 cfs brine pumping rate for the life of the project. Ponding areas would be formed by constructing a perimeter dike and interior dikes to form compartmented areas of about 10 acres each. After initial area grading perimeter dikes would be constructed with random fill. The pondside slopes and bottom of the interior area would be filled with a 2-foot impervious clay blanket or PVC liner to preclude underseepage. Slope protection of all pondside slopes would consist of 12 inches of quarry run stone. Heights of the interior and perimeter dikes would be 10 feet and 13 feet. The compartmented pond concept would minimize the hazard of ground water contamination should a leak in a pond cell occur. The estimated first cost and annual charges shown in Table 6-2 for Plan B are $125,000,000 and $5,200,000.

c. This alternative would have undesirable effects on the flora, fauna and aesthetics of the area. Extensive grading necessary to build the dikes around the brine ponds would destroy large areas of plant and animal habitat and create areas of barrenness in an area that already is depauperate of life. The land inundated by the brine ponds would be rendered useless as habitat because of salt accumulation. The ponds probably would be of little value as a fishery resource because of the high chloride content of the water. Recreational uses of the ponds probably would be insignificant because of the compartmentalized manner in which they would be arranged. If leaks developed in the perimeter dikes, adjacent vegetation would be killed by the high chloride content of the water. The system of brine ponds would detract from the natural scenery of the environment.

6.17 Plan C. Deep Well Injection.

a. Collection. This plan would consist of collecting and pumping the concentrated low flows in a manner similar to Plans A and B.

b. Disposal. Disposal would be by deep well injection. Several uncertainities were associated with the investigation of this plan.

c. Geological Considerations. Review of related deep well injection studies at Areas VI and XIII indicates that the only potential storage aquifer that may have sufficient capacity for large volume brine disposal would be the carbonate rocks at the base of the sedimentary section. These are Mississippian limestones and the Ellenburger group of Ordovician age. Maximum combined thickness appears to be less than 600 feet in the vicinity of Areas VII, VIII, and X; whereas the same section is several thousand feet thick in the Hardeman Basin, some 100 miles to the north. These pre-Pennsylvanian sediments were either never deposited over the structurally high granitics of the Red River Arch and Texas Peninsula or they were removed by erosion.

TABLE 6-2

ALTERNATIVE CONTROL METHODS

| Plan | Description | First Cost | Annual charge |
|---|---|---|---|
| | | $ | $ |
| A | Low flow dam collection and off-stream brine impoundment lakes | 42,100,000 | 2,000,000 |
| B | Low flow dam collection and off-stream evaporation pond disposal | 125,000,000 | 5,200,000 |
| C | Low flow dam collection and deep well injection | - | 3,000,000 |
| D | Advanced water treatment | - | 4,900,000 |
| E | Dilution by fresh water diversion via Trans-Texas Canal, Texas, water plan | - | 9,000,000 |

Note: Plan "A" was selected and has a benefit to cost ratio of 1.4 , as presented in "Chloride Control - Part 1, Arkansas-Red River Basins, Oklahoma, Texas, and Kansas, DM No. 3, General Design".

d. Active production of hydrocarbons from folded post-Mississippian sediments occurs in local structural highs, coincident with the surface emission of brines at Areas VII, VIII, and X. The respective related oil production is in the Johnson, Bateman, and J. Y. Fields. Injection into these basal sediments might cause possible damage, contamination, or adverse effects on mineral resources, whether hydrocarbons or ground water. The possibility of reactivating faults, thereby subjecting the area to undesirable seismic effects, must be considered. Because these possibilities, although somewhat remote, are highly unpredictable, injection wells would require extensive monitoring. Due to the poor injection potential at the source areas, injection sites would have to be several miles away, probably involving a field of wells. In addition, a large-scale exploration and testing program would be required to determine the areal extent of the reservoir, reservoir capacity, transmissivity rates, porosity, injection rates, instrumentation needs, and aquiclude conditions. The preliminary annual cost estimate of $3,000,000, shown in Table 6-2, was based on the assumption that a confined formation was present in the Ellenberger formation having ample capacity to accept the design disposal volume and located within an economical pumping distance of the brine source areas. This estimate is believed to be conservative. The cost could be substantially greater if disposal could not be accomplished in the project area.

e. The adverse environmental impacts of this plan would appear to be minimal as far as surface conditions are concerned; however, the subsurface impacts are highly unpredictable and at present more research is needed before meaningful statements can be made. The major surface impacts would be the destruction of some plant and animal habitat during the construction phase and the loss of some habitat in the inundated area behind the collection dams.

## 6.18 Plan D. Advanced Water Treatment.

a. Processes for Removal of Minerals. Six processes are currently being researched for demineralization of brackish water to an acceptable mineral level. These include ion exchange, reverse osmosis, distillation, electrodialysis, freezing, and electrochemical treatment. These processes are in various stages of development, but only the first four hold promise as practical processes for large volume demineralization. All desalination processes yield a brine effluent. Disposal of this treatment effluent presents a major technical problem in advancing demineralization technology. Plants located along coastal areas make it feasible to discharge effluent brines to the ocean. However, inland plants must employ solar evaporation lagoons or more sophisticated techniques for brine disposal.

b. Ion exchange can be an economical process if mineral solids of the source water do not exceed 1,000-1,500 mg/l. The brine emitting from the project source areas exceeds the 1,500 mg/l limit.

c. Reverse osmosis is a membrane process in which the feed water is forced through a membrane from a solution of high salt concentration to one of lower concentration. Because of the membrane fouling problem associated with high volume treatment rates, the method is most applicable to small volume treatment applications.

d. Distillation is now the most commonly practiced method for obtaining fresh water from brackish or sea water. Many commercial plants using the multistage flash distillation process are in operation throughout the world. These plants range in size from one to three million gallons per day (mgd) capacity product water and operate in the general cost range of $1.00 per thousand gallons. (From: Office of Saline Water, "Special Report on Status of Desalting, November 1970.") A number of detailed feasibility type engineering studies of larger plant capacities are being made by the Office of Saline Water. Aqua-Chem Incorporated has developed large scale plants in Mexico and Japan. Aqua-Chem assisted the District in completing a distillation plant feasibility study for the project. This study is discussed below.

e. Electrodialysis is another membrane process. Unlike reverse osmosis which uses pressure as the force to separate water from minerals, the energy in this process is electrical. However, as with reverse osmosis, membrane fouling has deterred large scale practical application.

f. "At this time, no single process, of the several being studied, is ready for full scale application and no single process has a clear and obvious advantage over the others. It bears repetition that a suitable method has to be found for disposal of the brine concentrates for any demineralization process." (US Department of the Interior, Federal Water Quality Administration, Division of Process Research and Development, "Current Status of Advanced Waste Treatment Processes," PPB 1704, July 1, 1970.)

g. Desalination Study. In February 1972 the District forwarded certain information to Aqua-Chem, Incorporated, Waukesha, Wisconsin, and requested that a preliminary cost proposal be prepared for project desalination plant development. Aqua-Chem replied that their investigations of the water quality problem of the Wichita River Basin showed multistage flash distillation plant treatment to be the most suitable treatment method. Also, Aqua-Chem related the following:

(1) Plant capital investment costs would range from $1,350,000 for a 1-mgd plant to $5,000,000 for a 5-mgd plant. Capital costs of plants greater than 5-mgd capacity would be about $1,000,000 for each additional mgd of capacity over 5 mgd.

(2) Based on project area natural gas cost schedules, energy costs would be about $0.20 per 1,000 gallons of product water.

(3) The plant effluent that would consist of about 35 percent of the plant feed water could be disposed by solar evaporation pond development. The District would need to add this cost to the cost of plant development.

(4) The economic life of the plants would be about 20 years.

(5) The plant product water would reduce chloride concentrations below 250 ppm. These data were used in development of the annual charge for the advanced water treatment plan. The estimated annual charge for Plan D, shown in Table 6-2 is $4,900,000.

(6) The major adverse environmental impacts of this alternative would be the destruction of plant and animal habitat during the construction phase of the treatment plant and the loss of habitat due to the extensive grading which would be necessary to build the system of evaporation ponds that would contain the brine effluents discharged from the plant. Graded areas and the brine ponds would destroy the natural environment and also the aesthetics of the region. The brine ponds, because of the extremely high salt content, probably would be insignificant as a resting place for migrant waterfowl or as recreational areas.

6.19 Plan E. Dilution by Diversion Waters of the Texas Water Plan.

a. Fresh-water lakes above the salt source areas were not considered as a diversion plan because of the small contributing drainage areas, high seepage and evaporation rates, and geological characteristics in the vicinity of the source areas. The plan considered involves the importation of good quality water from water surplus basins to dilute and enhance the water resource of the Wichita River Basin. The development of this plan was augmented by data taken from a report prepared for the Fort Worth District by the Brazos River Authority entitled "Report on Alternatives to Corps of Engineers Plans for Abatement of Natural Salt Pollution in the Brazos River." The plan would provide for dilution water to be taken from the Trans-Texas Canal of the proposed Texas water plan. Estimates of dilution water costs contained in the referenced report assume that water to be delivered to the project locale would come from surplus East Texas basin sources. The cost of dilution water was determined by the proportionate part of total costs of source water and additional cost of storage and conveyance facilities. As developed from cost data shown in Table 5 of the Brazos River Authority report, the estimated delivered cost of dilution water to the Wichita River Basin was $27 per acre-foot. The estimated average annual import volume required to obtain satisfactory dilution of the salt from source Areas VII, VIII, and X is about 335,000 acre-feet. Therefore, the estimated annual charge for Plan E, as shown in Table 6-1, is $9,000,000. In view of the comparatively high costs determined from preliminary investigation of this plan and uncertainties associated with development of the Texas water plan, further study does not appear desirable.

6.20 Other Control Methods. The following additional alternative control plans were investigated but discarded in view of the generally poor outlook for success.

6.21 Plan F. Variation of Plan A.

a. This plan would be similar to Plan A except that pumped brine from Areas VII, VIII, and X would be stored in a single brine lake at the Bluff Creek Basin site, about 2 miles northwest of Truscott. Studies for this plan have not progressed beyond the preliminary stage because:

b. The ultimate brine pool would impose a higher head on the brine dam abutments than the proposed plan and would therefore create a seepage hazard.

c. The higher pool would [illegible] fresh water springs located in the upper Bluff Creek Basin.

d. The first cost would be about eight million dollars more costly than the proposed plan.

6.22 Plan G. Variation of Plan B.

a. This plan would be similar to Plan B except that an evaporative spray system would be provided. The purpose of this system would be to increase the brine evaporation rate and thereby reduce the surface area requirement for the evaporation ponds. About 24,000 acre-feet of temporary storage would still be required for ponding flows during months when the evaporative rate would be low and for deposited salt and gypsum. Distribution lines for the spray system would be laid subsurface with riser pipes located at 50-foot centers. Wide spray, high pressure nozzles would be mounted on the riser pipes. Imponderables associated with preliminary investigation of this plan included: (1) the reliability of the spray system to function in a brine environment; and, (2) the operating costs. Results of the study showed that the costs for required mechanical-electrical equipment more than offset the potential savings by eliminating some of the brine ponds included in Plan B.

6.23 Plan H. Pipeline to the Gulf. This plan would consist of collecting the brine base flows at each of the pumping station sites in the recommended plan. These flows would then be pumped through a single pipeline system to the Lavaca Bay, for disposal in the Gulf of Mexico. The control plan would require an extensive pump and pipeline system over 400 miles in length. Preliminary cost estimates showed the plan to be several times more costly than the least costly alternative.

6.24 Plan I. Dilution with Ground Water. This plan would be similar to Plan E except dilution water would be imported from the Ogallala aquifer that underlies the Texas Panhandle. The water resource of the Ogallala aquifer has contributed greatly to the growth of the Texas High Plains economy. However, the water table surface is currently being mined and lowered from three to four feet per year by extensive withdrawals for irrigation. This situation is threatening the future economy of the Texas High Plains region. Tapping this diminishing water resource for dilution of mineralized low flows in the Wichita River would only worsen a currently serious water availability problem in the Texas Panhandle.

6.25 Plan J. Ruhr Type Disposal Method. The concept of this plan stems from water management practice within the Ruhr industrial area of West Germany. This area is one of the most concentrated industrial areas in the world. Water management has been successful there because the unique problems of waste disposal and water supply have been integrated into one system for planning and design. While most streams of the Ruhr area are used for water supply and other beneficial purposes, the Emscher, smallest of major area streams, is used exclusively for waste disposal. The concept for this project would be that the base brine flows could be pumped to the Brazos River or other stream of low value water resource. The plan would further pollute a potentially lower value resource to enhance and improve a potentially higher value water resource. Before a plan of this type could be investigated the legalities associated with inter-basin transfer of water and its effects would have to be resolved.

6.26 Plan K. Disposal by Irrigation. The control concept would be similar to Plan A except that tolerant plant growth on the uplands above the brine lakes would be irrigated with the pumped brine. This practice would increase the disposal rate and reduce the size of the brine lakes. Irrigation of salt-tolerant forage crops and phreatophytes with concentrated brine would separate salt from the applical solution by evapotranspiration. The osmotic process by which plants separate some minerals from water would cause the deposition of salt about the plant root system. Poor leaching characteristics of the insitu soils would result in an accumulation of salt in the upper topsoil zone. A sterile soil condition would be anticipated after the initial years of project operation. The build-up of a salt flat type of terrestrial ecosystem would be undesirable. Considerable research and experimentation would be required to determine what types of salt-tolerant plants could survive under varying brine concentrations and irrigation rates. Also, procedures for sizing the required reservoir to contain irrigation return flow and leaching water are not well defined. In view of the uncertainties associated with the plan, further study does not appear desirable.

6.27 Plan L. Interception of Subsurface Brine Springs. This plan would provide for the interception of subsurface brine before surface emission and dilution with streamflows. Preliminary study showed that achievement of the desired degree of control would fall short of the required goal. Results of geologic investigations revealed the brine emission mechanism to be complex. The chloride load enters the streams by springs, seeps, and recirculation and mixing of the riverflow and concentrated ground water alluvium and weathered zones. Where springs are present, sinks, caves, and solution cavities abound in the area, with valley walls marked by striking slump and collapse structure. Placement of additional hydrostatic head to capture the unconfined springs would result in further dispersion of the subsurface flow. The best plan to capture the brines is collection of the low surface flows below the source areas.

6.28 Plan M. Other Brine Storage Schemes Investigated.

a. Area VII. Alternative sites for Brine Dam VII were limited by poor geological characteristics within the region where storage is required. An alternative site was investigated on the upper reach of Blue Hole Creek, a north bank tributary of the North Fork Wichita River. The damsite is located about one mile north of the US Highway 70 crossing and about 17 miles southwest of the project document site. Foundation investigations showed the presence of several massive gypsum units. Surface depressions and sinks were evident in the reservoir area. These adverse geological features negated the potential for development. Additional geological surface reconnaissance showed that the project document site is located as near to the source area as is geologically feasible.

b. Areas VIII and X. Eight alternative brine storage plans were investigated to select the best brine storage scheme. The alternative sites are shown on plate 6-1 on page 6-29 of this section. Hydrologic data and costs, including the first costs and annual charges, and predominant geological characteristics associated with each plan investigated are shown in Table 6-3. Results of this study showed that although there was a decrease in project costs associated with development of the upper basin sites, the potential risk of brine seepage was higher than that associated with the lower basin sites. Also, known fresh water springs at the upper basin sites would be inundated. Therefore, Plan A was selected because it is the least costly of the two plans located entirely within the Choza shale, a relatively impervious formation.

6.29 Plan N. No Action. Construction of the control plan facilities could be postponed indefinitely with no improvement of the water resource of the Wichita River Basin. In addition, the no action alternative would jeopardize the plan of improvement for the water resource of the Arkansas and Red River Basins as the Wichita control plan is an integral part of the comprehensive Ark-Red Basins Chloride Control Project. The alternative for no development was the option presented to Congress when it decided to authorize the project for construction by Public Law 89-789 on 7 November 1966.

6.30 The no action alternative would allow for about 11,900 acres of relatively poor grazing land to remain that would otherwise ultimately be inundated by brine. About seven percent of the average flow into Lake Kemp would not be diverted as a result of pumping the highly concentrated brine base flows. Also the potential of brine seepage from the storage reservoirs and other impacts as described in Section III could be avoided.

6.31 The objective of the plan outlined in Senate Document 110, 89th Congress, 2d Session, was to implement the construction of control measures to improve the water resource of the Wichita River Basin. In conjunction with other chloride control measures authorized in the Arkansas-Red River Basins, and non-Federal interests'control of manmade brines, the water resource in the Ark-Red Basins could be improved. Lake Kemp water (190,000 acre-feet conservation storage) under existing conditions has chloride concentrations exceeding 1,000 mg/l, 50 percent of the time, with peak concentrations exceeding 1,300 mg/l, 2 percent of time. These concentrations are too high to meet minimum US Public Health Standards for municipal and industrial uses. With the proposed plan, the chloride concentrations would be lowered to exceed only 160 mg/l, 50 percent of the time, with peak concentrations exceeding 250 mg/l only 2 percent of the time. Therefore, these concentrations would meet US Public Health Service recommended chloride standards for minimum and industrial uses. This achievement would improve a water resource of limited use and would have a favorable impact throughout the water-starved region of the Wichita River Basin.

6.32 Although not a project purpose, flood control in the Bluff and Canal Creeks below the brine dams would be inherent with development of the proposed plan. The proposed brine lakes would store runoff above the brine dams up to a 100-year storm event occurring after 100 years of brine pumping. The brine lakes would be located in sparsely populated areas of natural scenic appeal and it is expected that visitors and casual sightseers would be attracted to the brine lakes. Also, these lakes after initial filling would develop the potential for water-oriented recreation. The project would further the current environmental goal of improving the quality of our flowing streams.

TABLE 6-3

BRINE DAMSITE SELECTION DATA

| Plan | Plan description | Top of dam elevation | Stages of construction | Areas VIII & X Costs: First cost $ | Areas VIII & X Costs: Annual charges $ | Geological characteristics |
|---|---|---|---|---|---|---|
| A | Survey Report<br>Locale, Axis C | 1512.0 | One | 25,500,000 | 1,100,000 | Good, Choza shale |
| B | Survey Report<br>Locale, Axis B | 1501.5 | One | 26,000,000 | 1,150,000 | Good, same as plan A |
| C | Truscott Site | 1566.0 | One | 26,000,000 | 1,160,000 | Fair, San Angelo |
| D | Auxiliary No. 3<br>Auxiliary No. 4<br>Survey Report, Axis B | 1583.0<br>1580.0<br>1457.5 | Two - 20-year life for auxiliary No. 3 and auxiliary No. 4 | 24,000,000 | 1,140,000 | Auxiliary No. 3 and No. 4 are poor to fair |
| E | Auxiliary No. 3<br>Survey Report, Axis B | 1582.0<br>1477.5 | One | 24,500,000 | 1,120,000 | Auxiliary No. 3 is poor<br>Axis "B" is good |
| F | Auxiliary No. 4<br>Auxiliary No. 5 | 1582.0<br>1580.0 | One | 23,500,000 | 1,090,000 | Fair, same as plan C |
| G | Auxiliary No. 3<br>Auxiliary No. 4 | 1591.5<br>1582.0 | One | 23,000,000 | 1,070,000 | Poor, same as plan D |
| H | Auxiliary No. 1<br>Auxiliary No. 3 | 1639.0<br>1591.5 | One | 22,000,000 | 1,010,000 | Very poor. Auxiliary No. 1 in flowerpot gypsum (Not a viable alternative) |

(1) The interest rate is 3¼% and the price level is based on January 1972 unit prices.

6.33 Finally, the no action alternative would result in excess economic outputs over costs being foregone that would otherwise accrue from the approved project. Based upon a conservative estimate of 7 mills per thousand gallons for improved water, the present worth of economic outputs foregone by the no action alternative would be $78,000,000.

6.34 <u>Comparative Economic and Environmental Analysis of Alternatives.</u>

National economy development (NED) and environmental quality outputs were developed for each of alternative Plans A, B, C. D. E and N (no action). The values derived are shown in Table 6-4

TABLE 6-4

PROJECT OUTPUTS

| Annual NED outputs | | Environmental Quality Outputs |
|---|---|---|
| | PLAN A | |
| Water quality improvement | $2,475,000 | 1. Aesthetics resulting from improved environment for aquatic life & adjacent streambanks |
| Flood control | 0 | 2. Enhancement of domestic and wildlife habitat because of improved water quality. |
| Total annual dollar outputs | $2,475,000 | 3. Improved quality of ground water in turn improves stream flow through the alluvium recharge. |
| Total annual costs (rounded) | $2,000,000 | 4. Encouragement of population stabilization in rural areas due to increased employment opportunities. |
| | | 5. Improvement of standards of living due to increased consumption in construction areas resulting from funds expenditures which will have a multiplier effect on local economies. |
| | | 6. Increased waterfowl habitat during spring and fall migrations. |
| | | 7. Large volumes of improved quality streamflow. |
| | | 8. Minor depletions of flows. |
| | | 9. Populations of salt-tolerant minnows would decline in the lower Wichita Basin due to competition from other species that would move upstream if water quality is improved. |
| Note: Incidental recreation benefits | $ 150,000 | 10. Possible contamination of local ground water in vicinity of Brine Lakes. |
| | | 11. Pasture land would be inundated. |

TABLE 6-4 (CONT)

| Annual NED Outputs | PLAN B | Environmental Quality Outputs |
|---|---|---|
| Water quality improvement | $2,475,000 | 1. Aesthetics resulting from improved environment for fresh water plant life. |
| Flood control | 0 | 2. Enhancement of domestic and wildlife habitat. |
| Total annual dollar output | $2,475,000 | 3. Improved quality of ground water. |
| Total annual costs (rounded) | $5,200,000 | 4. Encouragement of population dispersal and migration to rural areas. |
| | | 5. Improvement of standards of living in construction areas resulting from funds expenditures. |
| | | 6. Enhancement of waterfowl resting areas. |
| | | 7. Large volumes of improved quality streamflow. |
| | | 8. Minor depletions of flows |
| | | 9. Some salt water minnows would disappear from the streams in the lower Wichita Basin. |
| Note: Incidental recreation benefits | $ 45,000 | 10. Possible contamination of local ground water in vicinity of evaporation ponds. |
| | | 11. Pasture land would be inundated. |

TABLE 6.-4 (CONT)

| Annual NED Outputs | PLAN C | Environmental Quality Outputs |
|---|---|---|
| Water quality improvement | $2,475,000 | 1. Aesthetics resulting from improved environment for aquatic life. |
| Flood control | 0 | 2. Enhancement of domestic and wildlife habitat because of improved water quality. |
| Total annual dollar outputs | $2,475,000 | 3. Encouragement of population dispersal and migration to rural areas. |
| Total annual costs (rounded) | $3,000,000 | 4. Improvement of standards of living in construction areas resulting from funds expenditures. |
| | | 5. Large volumes of improved quality streamflow. |
| | | 6. Minor depletions of flows. |
| | | 7. Populations of salt-tolerant minnows would decline in the lower Wichita Basin due to competition from other species that would move upstream if water quality is improved. |

TABLE 6-4 (CONT)

| Annual NED Outputs | | Environmental Quality Outputs |
|---|---|---|
| | PLAN D | |
| Water quality improvement | $2,900,000 | 1. Aesthetics resulting from improved environment for aquatic life. |
| Flood control | 0 | 2. Enhancement of domestic and wildlife habitat because of improved water quality. |
| Total annual dollars outputs | $2,900,000 | 3. Improved quality of ground water. |
| Total annual costs | $4,900,000 | 4. Encouragement of population dispersal and migration to rural areas. |
| | | 5. Improvement of standards of living in construction areas resulting from funds expenditures. |
| | | 6. Large volumes of improved quality streamflow. |
| | | 7. Minor depletions of flows. |
| | | 8. Populations of salt-tolerant minnows would decline in the lower Wichita Basin due to competition from other species that would move upstream if water quality is improved. |

TABLE 6-4 (CONT)

| Annual NED Outputs | | Environmental Quality Outputs |
|---|---|---|
| | PLAN E | |
| Water quality benefits | $4,800,000 | 1. Aesthetics resulting from improved environment for aquatic plant life. |
| Flood control | 0 | 2. Enhancement of domestic and wildlife habitat because of improved water quality. |
| Agricultural | 1,000,000 | 3. Improved quality of ground water. |
| Total annual dollar outputs | $5,800,000 | 4. Encouragement of population dispersal and migration to rural areas. |
| Total annual costs (rounded) | $9,000,000 | 5. Improvement of standards of living in construction areas resulting from funds expenditures. |
| | | 6. Large volumes of improved quality streamflow. |
| | | 7. Increased volume of water in Wichita and Red River Basins. |
| | | 8. Populations of salt-tolerant minnows would decline in the lower Wichita Basin due to competition from other species that would move upstream if water quality is improved. |

TABLE 6-4 (CONT)

| Annual NED Outputs | Environmental Quality Outputs |
|---|---|
| **PLAN N - No Action** | |
| | 1. Large quantities of basin waters would continue to be degraded.<br>2. The opportunity for potential improvement on regional economy would be lost.<br>3. No enhancement of domestic and wildlife habitat would occur as a result of improved water quality.<br>4. The present ecosystem at the source areas would be maintained.<br>5. No crop or pastureland would be lost. |

6.35 Summary and Conclusions. All reasonable and viable alternatives to the Wichita River Basin chloride control plan have been investigated. The favorable impact of the project would be that the water resource of the Wichita River Basin would be improved and with non-Federal interest control of the manmade brines and control of the remaining natural salt areas the water resources of Lake Texoma and the Red River would be improved. The water quality improvements would result in widespread benefits to the population within the area influenced by the Wichita River. These widespread benefits would more than offset the local adverse environmental effects that could not be avoided should the proposal be implemented.

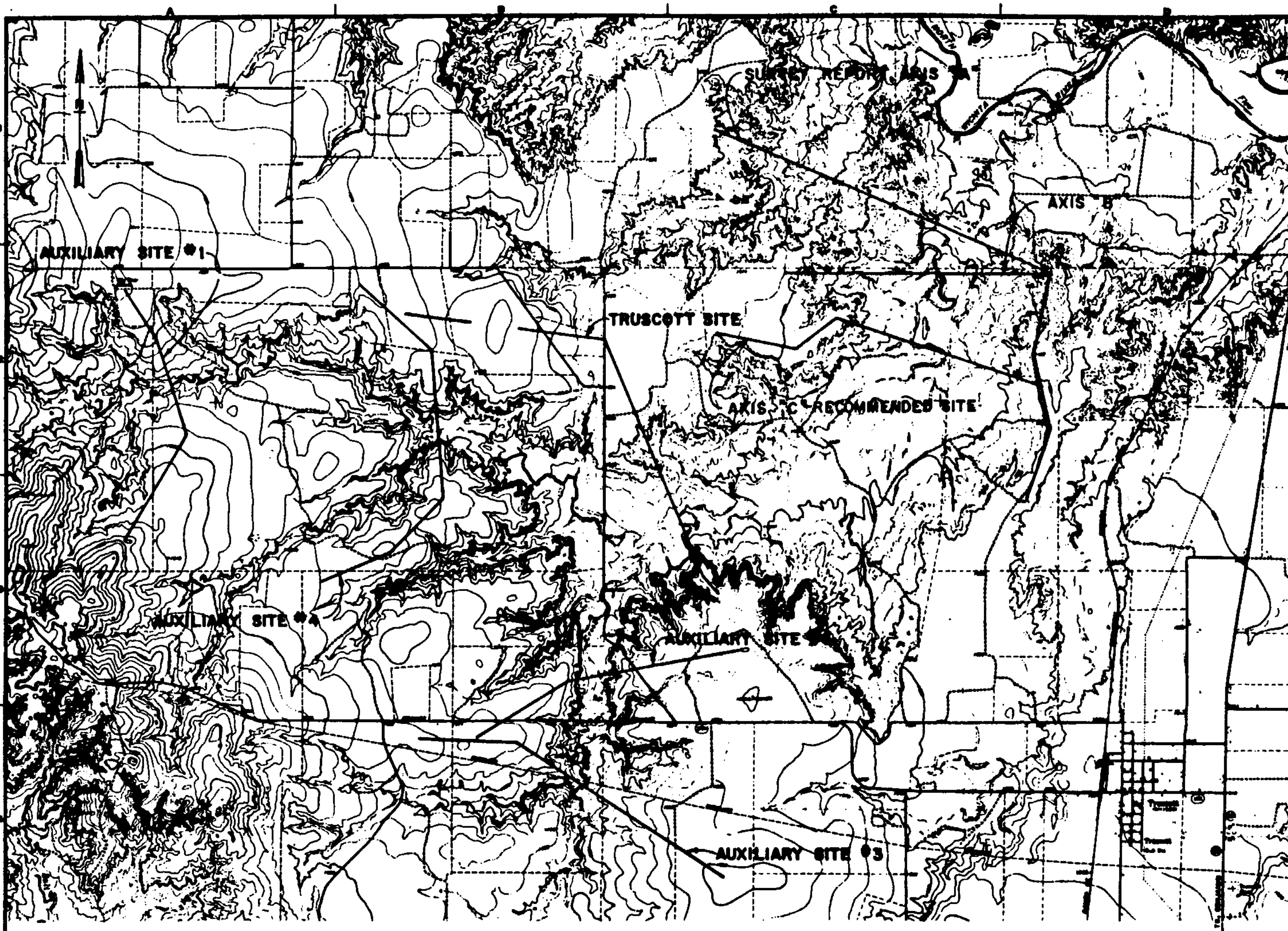
6.36 The impacts of numerous alternative actions have been balanced against the proposed action in terms of natural environment, human life quality and economics. The net losses to the environment which would occur with development of the selected control plan are small when weighed against the potential gains in meeting human needs. Therefore, the control of chloride pollution and improvement in the water quality of the Wichita River Basin is the best choice for the benefit of mankind.

## ALTERNATIVES FOR THE DEVELOPMENT OF

## AREAS VI, IX , XIII, XIV and XV

6.37 Alternatives Studied before Project Authorization. Under authority of the Federal Water Pollution Control Act, Public Law 660 (84th Congress), Public Health Service began a report of the Arkansas and Red River Basins natural chloride pollution in July 1957 entitled "Water Quality Conservation, Arkansas-Red River Basins". The Corps of Engineers findings were presented in a two-part survey report in response to a 16 December 1959 study authorization that read:

> "Resolved by the Committee on Public Works of the United States Senate, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act, approved June 13, 1902, be, and is hereby, requested to review the report of the Chief of Engineers on the Arkansas River and tributaries, Kansas, Oklahoma, and Arkansas, published as House Document No. 308, Seventy-fourth Congress, and the report on the Red River and tributaries, Arkansas, Louisiana, Oklahoma, and Texas, published as House Document numbered 378, Seventy-fourth Congress, and other pertinent reports, with a view to determining in cooperation with the Division of Water Supply and Pollution Control, Public Health Service, methods and means of improving and managing water quality in the Arkansas and Red River Basins."




**PLAN**

SCALE OF FEET

U.S. ARMY ENGINEER DISTRICT, TULSA
CORPS OF ENGINEERS
TULSA, OKLAHOMA

ARKANSAS-RED RIVER BASINS
CHLORIDE CONTROL

WICHITA RIVER BASIN (AREAS XII, XIII & X)
AREAS XIII & X
ALTERNATIVE BRINE DAMSITES

DEC. 1972

PLATE 6-1

6.38 Project Authorization. Part II of the Arkansas-Red River Basin Water Quality Control Study for Areas VI, IX, XIII, XIV, and XV in the Red River Basin, and Areas I thru IV in the Arkansas River Basin, was authorized by the Flood Control Act of 1970 approved 31 December 1970 (Public Law 91-611). As recommended by the Chief of Engineers in his report dated 6 May 1970, that Public Law modified the 1966 Flood Control Act to include Part II.

6.39 General. Alternatives for the Red River Basin Areas VI, IX, XIII-XIV, and XV, were developed for various levels of chloride removal. Alternative plans were developed in two manners, the first are general alternatives which develop a system plan for the salt areas and the second type are alternatives which are specific for each salt emission area. The following alternatives would provide general approaches to alleviate the chloride problem.

a. Pipeline to the Gulf of Mexico. The general plan for a pipeline to the Gulf of Mexico consists of collection systems at the salt areas, pump stations to pump the collected brine to a main trunk pipeline that would have intermediate pump stations spaced to pump the brine to the Gulf of Mexico. The length of the pipeline would be approximately 480 miles. It would require 52 pump stations. Energy requirements would be excessively high to pump the brine as the pipeline traverses the State of Texas to the Gulf of Mexico, just south of Freeport, Texas. The pipeline to the Gulf of Mexico alternative would utilize one of the following collection systems, as dictated by the particular source area: subsurface cutoff walls, well-points, low flow dams, or shallow wells. Any one of these, singly or in combination, could be combined to provide a collection system for the various areas. The brine for this pipeline would be collected from the following areas in the Red River: Areas VI, IX, XIII, XIV, and XV; and in the Wichita River Project: Areas VII, VIII, and X. The disposal system for this plan would be a pipeline which would convey the brine to the Gulf of Mexico, utilizing pump stations to keep the brine flowing. The pipeline would be reinforced concrete, lined with a protective coating that is inert to brine. The pipeline size would vary from 12 inches to 84 inches in diameter, depending on the location of the line, relative to the total collection and disposal system. Under this plan, a total of 84.5 c.f.s. (42,250 g.p.m) would be collected and transported through 42 and 84-inch pipe to the Gulf. The pump stations were designed to boost

SUMMARY ECONOMIC INFORMATION

ECONOMIC DATA EXTRACTED FROM
US ARMY CORPS OF ENGINEERS
GENERAL DESIGN MEMORANDUM
ARKANSAS-RED RIVER BASIN CHLORIDE CONTROL
TEXAS, OKLAHOMA, AND KANSAS
(RED RIVER BASIN)

DESIGN MEMORANDUM NO. 25
GENERAL DESIGN
PHASE I - PLAN FORMULATION

COMPLETE DOCUMENT IS AVAILABLE
AT US ARMY ENGINEER
DISTRICT, TULSA, OK

PROPOSED RED RIVER CHLORIDE CONTROL DATA

SUMMARY OF TANGIBLE BENEFITS
(July 1976 Prices)

| | |
|---|---|
| Water quality | $ 17,317,200 |
| Redevelopment | 48,600 |
| Total | $ 17,365,800 |
| TOTAL FIRST COST | $124,000,000 |
| Annual Costs (Includes interest and amortization, operation and maintenance, and replacements) | $ 8,025,000 |
| Benefit-to-cost ratio | 2.2 |

the pressure in the line when the velocity dropped below 1.5 feet per second. The pumps were sized to pump the peak flow at that particular point in the pumping system. Since a standby pump was included in each pump station, the controls would activate the standby pump during peak flow conditions. Each individual pump could pump the average flow, but both pumps would pump the peak flow. The cost of the pumps included variable speed drives to increase the pumping capacity as the flow of brine increased or decreased, as the case may be. The pump stations were simply designed, 20 feet square, reinforced concrete buildings with electrically-driven motors and motor control panels. There would be 28 river crossings, 70 highway crossings, 21 railroad crossings and 120 creek crossings in the route selected for the study. The river crossings were designed to be standard inverted siphon. The highway crossing would be bored and consist of a steel liner and transmission pipe. The creek crossings follow the natural terrain but would be three feet below the ground level. The pipeline to the Gulf alternative system of disposing of brine had a first cost of one billion dollars and an annual cost of 71 million dollars. Disposal of brines to the Gulf would have adverse effects on the marine communities located along the coast. A reduction in the yield of marine life, accompanied by diminution in recreational uses of the Gulf would be expected. In addition, pollution to soil and water resulting from deterioration of the pipe is probable for a long pipeline to the Gulf. The construction time of ten years would be excessive. Therefore, due to excessive cost and time, the pipeline to the Gulf alternative is not considered a feasible system for the Red River chloride control project.

b. Importation of Water for Dilution. The general plan for importing water for dilution of brine water would consist of a series of dams and canals in river basins where water would be of sufficiently high quality to justify pumping upstream solely to be utilized as mixing water. One plan would consist of importation of water to Lake Texoma. This plan would consist of dams downstream and would include pump stations and open canals, to convey water to Lake Texoma for dilution purposes. There are several disadvantages with this plan. The greatest disadvantage being that people downstream on high quality tributaries do not want to give up "their" water for dilution of brine water in Lake Texoma for use elsewhere. In the event that this plan would be selected as a viable alternative, a political argument would follow over whose water would be transported upstream, how it is to be used, and who would pay for the transportation cost. There would also be a problem of selecting an agency or political subdivision to set up the mechanism whereby water could be transported across basins for dilution purposes. Another alternative considered would be to construct fresh water lakes upstream of Lake Texoma to store fresh water that could be released to dilute the brine flows. The potential use of upstream lakes was abandoned because of the geological problems involved in building fresh water lakes in the area, and because high evaporation rates would make it practically infeasible to build such a system of lakes. The rainfall in the area upstream of Lake Texoma has an erratic pattern and would not lend itself to a system of fresh water lakes. The estimated annual water required to be imported from downstream or upstream fresh water lakes would be about one million acre-feet a year. The cost was estimated to be in excess of $100 an acre-foot. The annual cost would be approximately 22 million dollars. Importation of out-of-basin water would be highly controversial, due to transbasin laws of the states of Oklahoma, Texas, Louisiana, and Arkansas. Since a Red River compact has yet to be consummated between the four states, importation of water from downstream fresh water sources would be an unrealistic answer to solving the problem of brine in the Red River waters, originating in the upper basin. Importation of fresh water from the Mississippi River would be even more costly, according to a report by the Bureau of Reclamation which was done jointly with the Corps of Engineers and the Mississippi River Commission. That report indicated that the cost of water transported from the Mississippi River Basin to the high plains of Texas and New Mexico would exceed the benefits by about a five to one ratio. Since all costs were considered excessive, and considering the political implications of a plan of importation of water for dilution purposes, it is considered to be an unviable alternative.

6.40 Collection Systems. The various collection systems developed for the alternative studies include subsurface cutoff walls, low flow dams, well points, shallow wells, and total impoundment.

a. Subsurface Cutoff Wall. This system consists of a concrete cutoff wall down to bedrock with a perforated collection pipe, with lateral infiltration lines. The infiltration lines are set in a select filter bed that is located upstream and situated so that the drain pipe would flow by gravity to a sump. The brine would be pumped from the sump through a pipeline system to the disposal area.

b. Low Flow Dams. Low flow dams would channel the creek flow through a restricted area in the streambed. The brine would be impounded behind the low head dam and would be drained into a sump and pumped to a disposal system. The low flow dam would have a deflatable dam in the weir section which would be designed to deflate to allow floods to pass unimpeded.

c. Well Points. This alternative consists of a system of well points designed to collect the subsurface brine by suction and then pump the brine to a sump by a collection header pipe. The header pipe and pumps would be located in an area which would not be subject to flooding. From the sump, the brine would be pumped to the main trunk line going to the disposal facility.

d. Shallow Wells. This system consists of a specified number of wells drilled five to ten feet into bedrock. The location of the wells would be confined geographically to the salt emission areas. Each well would have a submergible pump for collecting the brine flow in the top of the bedrock and would have remote motor controls on the surface. The wells would be connected by a common header pipe. From there, the brine would be pumped to a disposal system. This type system would collect the brine at each salt area before the brine water flows to the surface or enters the alluvium.

e. Total Impoundment. Total impoundment consists of a brine dam which would be located on the stream below the chloride source. The dam would be sized to retain an accumulation of 100 years of runoff and a 100-year flood.

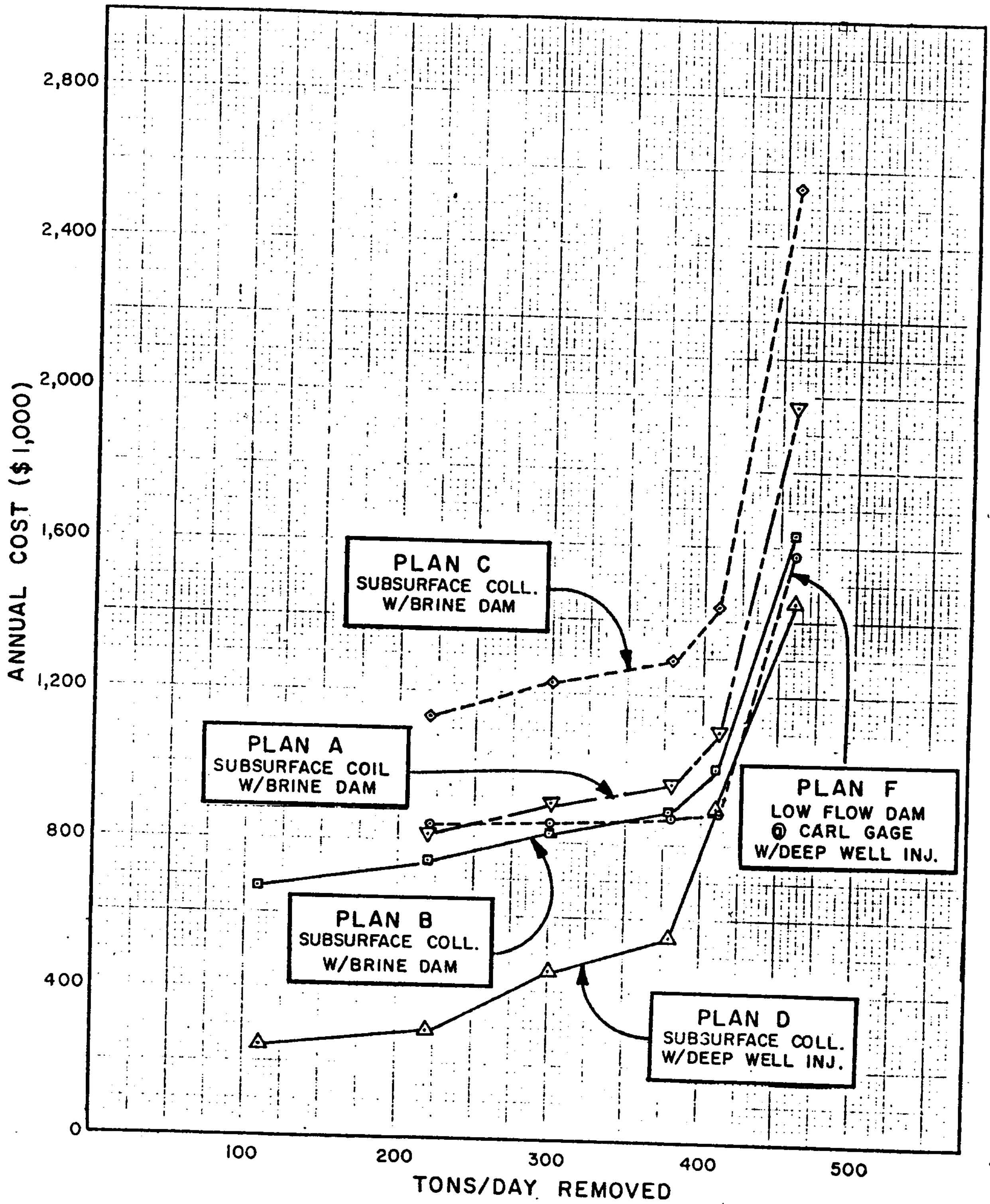
6.41 Disposal Facilities. Two disposal systems were developed which could be combined with the various collection systems. The two types of systems are discussed below:

a. Brine Impoundment Lakes. A brine dam would be built to impound the brine water and to serve as an evaporation pond. The upstream side of the dam would be protected by a layer of soil cement and the dam would be made of impervious earthfill.

b. Deep Well Injection. Brine water would be pumped from a collection system to a treatment station where it would be chemically treated and filtered. Deep wells would be drilled in a geological formation in the area known to possess adequate porosity and permeability. The treated brine water would then be disposed of by pumping it down the well

6.42 Alternative Plans for Area VI. Specific alternatives, including both collection and disposal systems for Salt Area VI, are discussed in the following subparagraphs. Cost curves for various tons of chlorides removed per day for each alternative are shown on figure 6-1. The total chloride load from Area VI at the Carl Gage is about 510 tons per day.

a. Plan A - Subsurface Collection and Brine Dam. This alternative would consist of a total system for removal of chlorides for Areas VI. The collection system would consist of subsurface cutoff walls in each of the three canyons. The cutoff wall would be located 500 feet up Kiser Canyon, 600 feet up Robinson Canyon, and 1,700 feet up Salton Canyon. The brine from each canyon would be collected in a filter bed and transferred by a feeder line to a sump. From there, the brine would be pumped to the brine dam. All pipe would be PVC-lined standard steel pipe. The disposal system would consist of the brine being pumped approximately three miles from the collection site to an evaporation lake formed by the Fish Creek Dam. The dam would be about 3,000 feet long and the evaporation lake would have a surface area of about 2,200 acres at the maximum level of control. Cost estimates were developed for four different tons per day (T/D) removal: 220,300,380, and 420 which relate to 0.5, 1.0, 1.4, and 5.0 c.f.s. average flows, respectively. The 220




AREA VI

Figure 6-1

T/D plan would collect brine from Salton Canyon only and would have one pump station. The 300 T/D plan would collect brine from Salton and Robinson Canyons and have two pump stations. The 380 T/D plan would collect brine from all canyons and have three pump stations. In addition to the cutoff wall collection in the canyons, the 420 T/D plan would have a wellpoint system in the Elk Fork River, which would collect brines originating about the three area canyons and along the canyon walls of the Elm Fork. This plan would require four pump stations.

b. Plan B - Subsurface Collection and Brine Dam. Plan B would consist of a total system for removal of chlorides from Area VI. The collection, pumping, and disposal systems used in Plan B are the same as Plan A. The only major difference between these two plans would be the location of the brine dam. The brine dam for Plan B would be located about two miles downstream of the Fish Creek site used in Plan A. The evaporation pond would be about the same size in both surface acres and length of dam.

c. Plan C - Subsurface Collection and Brine Dam. Plan C would consist of a total system for removal of chlorides from Area VI. The collection, pumping, and disposal systems used in Plan C are the same as used for Plan A. The only major difference between Plan C and Plan B is the location of the brine dam. The brine dam for Plan C would be located approximately four miles downstream from the Fish Creek site at North Bank Tributary site. The evaporation pond would have about the same surface acres as in Plans A and B, but the dam length would be about 4,500 feet.

d. Plan D - Subsurface Collection and Deep Well Injection. This plan would utilize deep well injection to dispose of the brine. The collection system would be the same as that outlined in Plan A. The brine from the collection systems would be pumped by pipeline for approximately 15 miles to a holding area where it would be treated as required. The treated brine would then be injected into a disposal well. The cost of this plan would include a treatment plant, injection pumps at the well head, and intermediate pump stations.

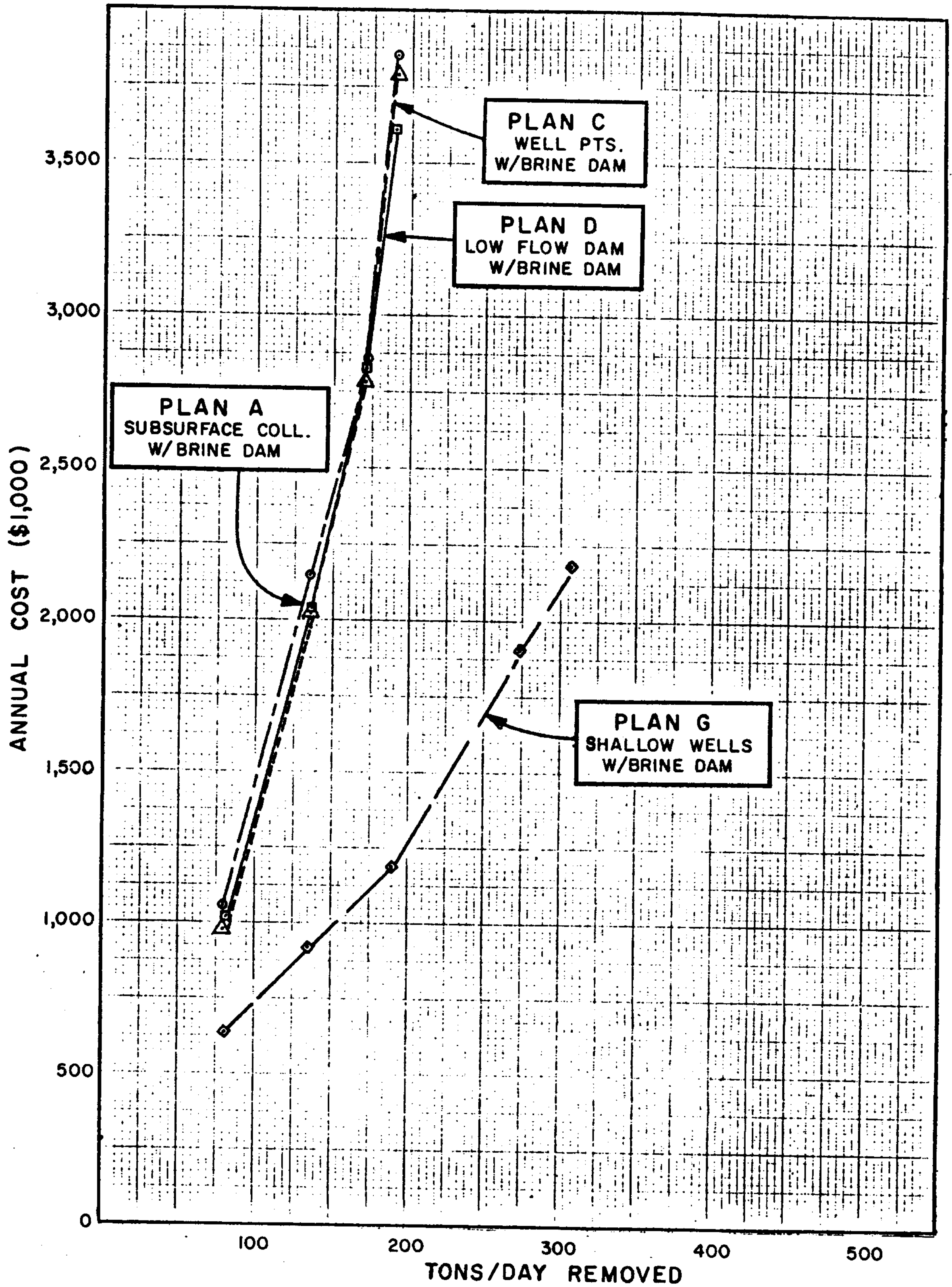
e. Plan E - Desalination. Plan E would be a total system for controlling the natural chloride emissions from Area VI, utilizing desalination. Desalting consists of converting feedwater into product water and concentrated waste brine. The plan would use a subsurface cutoff system for collection of feedwater. One collection site would be located in each canyon. The feedwater would then be pumped by feeder lines into a main line for transport to the desalination plant. The pipe would be PVC-lined standard steel pipe. After processing, the product water would be pumped into the Elm Fork of the North Fork of the Red River or put to some other beneficial use. The effluent would then be pumped thru a PVC-lined steel pipe approximately two and one-half miles to the Fish Creek damsite utilized in Plan A. A brine impoundment dam would be built at this location for the disposal system.

f. Plan F -Low Flow Dam Collection and Brine Dam. Plan F consists of a total system for removal of chlorides from Area VI. The collection system would utilize a low flow dam at the Carl Gage Station on the Elm Fork which would span the stream channel. The dam would have a length of 500 feet with a 7-foot weir height. The collected brine would be pumped to an evaporation pond created by a brine dam at the Fish Creek survey site.

g. Costs. Estimates of costs were made for several chloride removal rates for the various combinations of collection and disposal systems. Annual costs were computed using January 1974 price levels, a 5-7/8 percent interest rate, a 100-year amortization period, plus annual operation, maintenance, and major replacement costs. The annual cost curve for the various plans is shown on Figure 6-1.

6.43 Alternative Plans for Area IX. Specific alternatives, including both collection and disposal systems for Salt Area IX, are discussed in the following subparagraphs. Cost curves for various levels of chlorides removed in tons per day (T/D) for each alternative are shown on Figure 6-2. The total chloride load from Area IX is about 340 tons per day.

a. Plan A - Subsurface Collection and Brine Impoundment. This alternative would use subsurface cutoff walls as the collection system. The Middle Pease River would have two cutoff walls below each of the salt sources. The North Pease River would also have two cutoff walls below its salt source. The brine would be collected in a filter bed and transferred by feeder line to a sump where it would be pumped to the brine dam. The disposal system consists of the brine being pumped approximately 21 miles from the collection site to an evaporation pond formed by the Canal Creek damsite at river mile 1.6. That location would be the nearest location of a suitable geologic region where brine would be stored with minimum possible leaks. Due to the large distance and fluctuating elevations between the collection system locations and the brine dam location, it was necessary to have a junction pump station to pump the brine to the dam. Pipe used would be PVC-lines standard steel pipe, except for laterals in the streambed which would be PVC only. Cost estimates were developed for four average levels of tons per day (T/D) removed: 79, 135, 171, and 190, which relate to 3.0, 6.5, 9.5, and 13.5 c.f.s., respectively. The 79 T/D plan would collect brine from the Middle Pease River and have two pump stations and one junction pump station. The remaining plans would collect brine from the North and Middle Pease Rivers and have four pump stations and one junction pump station. Each pump station would have backup pumps.




**AREA IX**

Figure 6-2

b. Plan B - Subsurface Collection and Deep Well Injection. The collection system for Plan B would be the same as used in Plan A. The disposal system would consist of brine being pumped from the subsurface collection system to deep wells for injection into the Ellenberger Formation. PVC-lined standard steel pipe would be used to transport the brine (2,800 feet to 7,000 feet) from the collection site to the disposal site. Four injection wells on the North Pease River and five on the Middle Pease River would be required. However, studies showed that no adequate subsurface formation for deep well injection was available in the area and no further consideration was given to this plan.

c. Plan C - Well Point Collection and Brine Impoundment. The collection system utilized for Plan C would be a well point system. There would be 4 to 10 well point collection systems located near each salt source in the North and Middle Pease Rivers. The 79 T/D removal would have 4 well point systems at two locations in the Middle Pease River. To remove 135 T/D, 4 well point systems at two locations in the Middle Pease River. To remove 135 T/D, 4 well point systems at two locations in the North Pease and 6 well point systems at two locations in the Middle Pease River would be required. The 171 T/D removal would require 6 well point systems at two locations in the North Pease and 8 well point systems at two locations in the Middle Pease River. The 190 T/D level would require 8 well point systems at two locations in the North Pease and 10 well point systems at two locations in the Middle Pease River. The brine would be collected from each system in the riverbed and delivered to a pump station near the river bank for transport by pipeline to the disposal system. All pipe utilized would be PVC-lined standard steel pipe, except for the laterals in the streambed which are PVC only. The disposal system consists of the brine being pumped approximately 21 miles by pipeline from the collection system to an evaporation pond formed by the Canal Creek Dam at river mile 1.6 as in Plan A.

d. Plan D - Low Flow Dam and Brine Impoundment. The collection system utilized for this plan would be low flow dams. There would be low flow dams at two locations on each river. The 79 T/D level would have two low flow dams on the Middle Pease River. The remaining levels of removal would have two low flow dams on both the North and Middle Pease Rivers. After the brine has been collected by the dam, it would be pumped by pipeline to the disposal system described in Plan A.

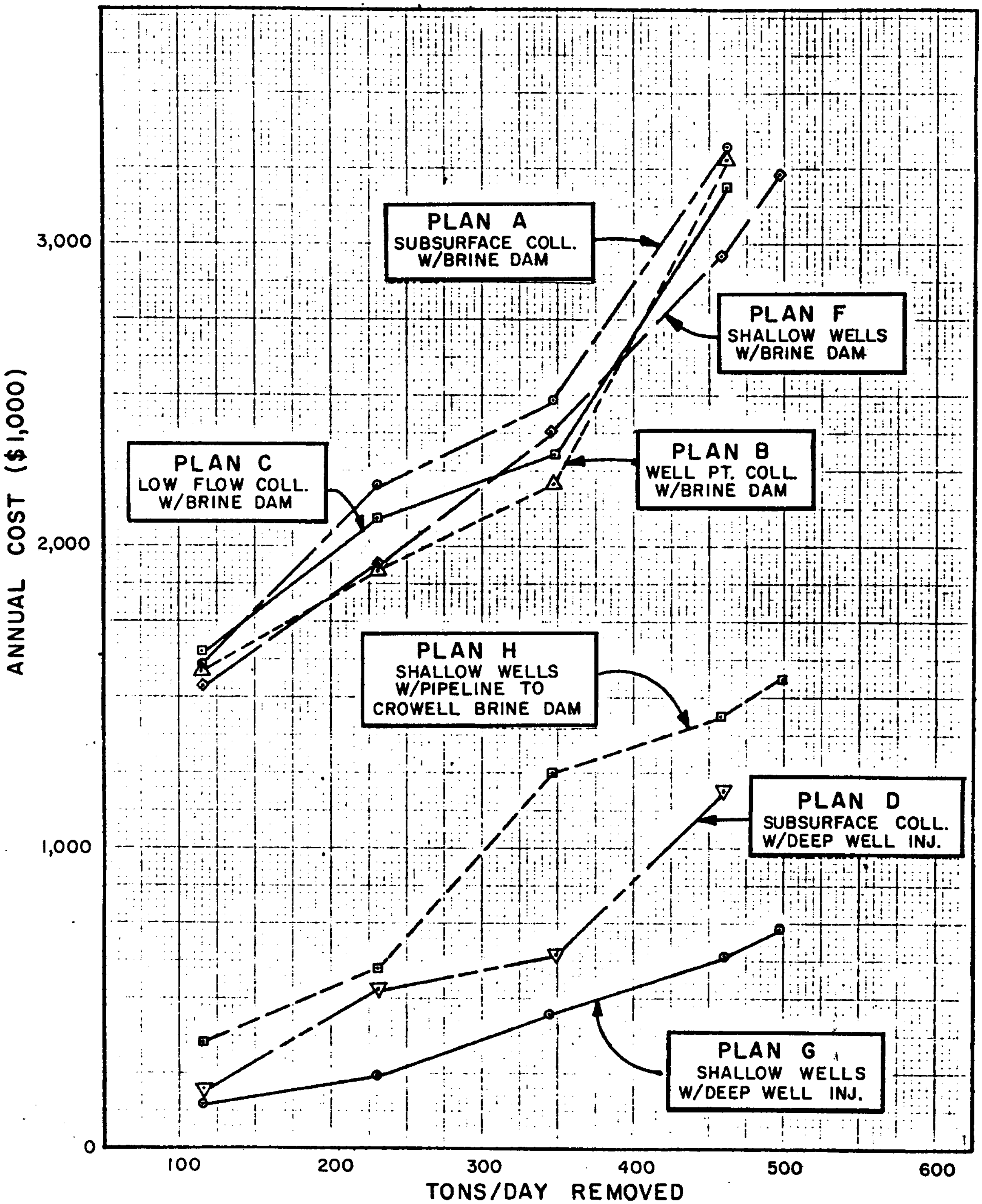
e. Plan E - Total Impoundment. Plan E would consist of a total impoundment dam at river mile 41.1 on the Pease River. That project would control 98% of the chlorides from Area IX. Studies indicated that the nearest damsite where the geological formations would allow a brine impoundment was 35 miles downstream from Area IX salt sources. Preliminary studies indicated that the brine impoundment would have a high cost and that the elevation of the required pool would back brine waters into a poor geologic area which would result in leakage. For those reasons, no further studies were made of this plan.

f. Plan F - Desalination. Desalination was considered as an alternative for chloride control in Area IX which has high base flows and low chloride concentrations. The average flow is 17 c.f.s, which would require a 2.3 to 10.8 m.g.d. plant capacity to handle the base flows of the North and Middle Pease Rivers. Due to the volume of water being processed, a large desalination plant would be needed to desalt the low concentration chlorides from the feed water. An estimate of only the treatment cost would range from a minimum of $14.6 million to a maximum of $41.1 million first costs (annual cost would be $2.3 to $7.75 million). With collection and disposal system costs included, the total cost for the system would have a first cost of from $31.7 to $96.8 million.

g. Plan G - Shallow Well Collection and Brine Impoundment. The collection facility utilized for Plan G would be the shallow well system. The wells would be spaced about 250 feet apart and would collect the brine at each principal salt emission area before the brine water flows to the surface or enters the alluvium. The objective would be to construct enough shallow wells in each emission area to collect the amount of brine flow necessary to achieve the designated level of control. Each of the wells would be drilled so that each pump would be five to ten feet into the bedrock (for Area IX, this means an average depth of 25 to 30 feet). Each well would be encased with a steel pipe with PVC liner. Within each casing would be a submergible pump designed for corrosion-resistant (bronze, brass or stainless steel) exposure. Remote motor controls would be located above the surface for ease of servicing. Each well would have a PVC-discharge pipe that is connected to a common header pipe. The header would connect to a transmission pipe which transports the brine to the disposal system. The disposal system would be the same as discussed in Plan A. Cost estimates were developed for six average levels of tons per day (T/D): 79, 136, 171, 190, 273, and 307, which relate to 2.5, 4.3, 5.4, 6.1, 9.7, and 11.0 c.f.s., respectively. Chloride removal rates of up to 190 T/D are from the Middle Pease River only. Removal rates of 273 T/D and higher collect brine from both Middle and North Pease Rivers. Annual cost curves for the alternative plans are shown on Figure 6-2.

6.44 Alternative Plans for Area XIII-XIV. Specific alternatives providing a total system for the removal of chlorides from Areas XIII and XIV are discussed in the following subparagraphs. Cost curves for various levels of chlorides removed in tons per day (T/D) for the alternative plans are shown on Figure 6-3. Those curves include the annual cost of the existing collection systems presently in operation on Jonah Creek since it would be a part of each alternative studies.

a. Plan A - Subsurface Collection and Brine Impoundment. The collection system utilized for Areas XIII and XIV would be subsurface cutoff walls. There would be two subsurface systems in Area XIII, one of which is in use at the present time as part of the experimental work




AREA XIII & XIV

Figure 6-3

(Jonah Creek Salt Area) and one subsurface system at Area XIV. To remove 115 T/D, the existing Jonah Creek collection system would be utilized and a new subsurface cutoff system would be installed approximately 1.2 miles downstream. At the 229 T/D level of removal, the existing collection system would be supplemented by another subsurface system located approximately 2.3 miles south of the existing system near the point where Jonah Creek enters the Prairie Dog Town Fork of Red River. The dam site could also be utilized at the 347 T/D level of removal when combined with the existing collection system. At the 462 T/D level of removal, two collection systems would be required in addition to the existing system. One subsurface system would be at the same location as the 229 T/D and 347 T/D levels on Jonah Creek and the other would be installed in Salt Creek, near its confluence with Red River. The brine would be collected in a filter bed and transferred by a feeder line to a sump where it would be pumped to a booster pump station. From that point, the brine would be pumped through a pipeline to the Dry Salt Creek brine dam. The disposal system would consist of an evaporation pond formed by the Dry Salt Creek Dam. The dam would be located about 12 miles north of Estelline, Texas, in Hall, Childress, and Collingsworth Counties. All pipe used in the disposal system would be PVC-lined standard steel pipe. Depending on the amount of chloride removed, the evaporation pond would vary from about 1,400 to 2,500 acres in surface area and the length of the dam would vary from 5,600 to 11,000 feet. Cost estimates were based on the following removal rates: 115, 229, 347, and 462 tons per day, which relates to 1.4, 2.8, 4.3, and 6.5 c.f.s., respectively. The 115, 229, and 347 T/D removal plans would collect brine from only Area XIII salt source. The 462 T/D plan would collect brine from both Area XIII and XIV salt sources. Pump stations would have pumps available for standby service.

b. Plan B - Well Point Collection and Brine Impoundment. The collection system utilized for this plan would be the well point system. Depending on the removal rate, there would be four to sixteen well point collection systems located near each salt source. Each system consists of 215 well points. The existing collection system presently in use on Jonah Creek would become a part of each total system at each level of control. The 115 T/D plan would have four well point systems on Jonah Creek, located approximately 1.2 miles downstream of the existing collection system. The 229 T/D plan would have eight well point systems located 2.3 miles downstream from the existing system near the point where Jonah Creek enters the Prairie Dog Town Fork of Red River. That site would require 12 well point systems at the 347 T/D removal rate and 16 well point systems at the 462 T/D level. The 462 T/D level of removal would require an additional 12 well point collection systems in Area XIV on Salt Creek near its confluence with Red River.

The brine would be collected from each system in the riverbed and delivered to a sump near the river bank for transport by pipeline to a central booster pump station. From that point, the brine would be pumped to the disposal system. The disposal system consists of pumping brine to the brine impoundment dam as discussed in Plan A. Cost estimates were developed for the same levels of chloride removals as Plan A.

c. Plan C - Low Flow Dam and Brine Impoundment. The collection system utilized in this plan is the low flow dam. There would be two collection systems at Area XIII, one of which is already in use at the Jonah Creek Salt Area and one low flow dam in Area XIV. At the 115 T/D level of removal, the existing collection system would be utilized and a new low flow dam would be installed approximately 1.2 miles downstream At the 229 T/D removal level, the existing collection system would be supplemented by a low flow dam located approximately 2.3 miles south of the present system near the point where Jonah Creek enters the Prairie Dog Town Fork of Red River. That site would also be utilized at the 347 T/D removal rate along with the existing collection system. At the 462 T/D level, there would be two collection systems utilized in addition to the existing system. One low flow dam would be at the same location discussed for 347 and 476 T/D removal rates and the other would be installed on Salt Creek near its confluence with Red River. The disposal system consists of the brine being pumped to the brine impoundment dam discussed in Plans A and B.

d. Plan D - Subsurface Collection and Deep Well Injection. The collection system utilized for this plan would be subsurface cutoff walls which is the same system described in Plan A. The disposal system would consist of the brine being pumped from the subsurface collection system to deep wells for injection into the Ellenburger Formation. PVC-lined standard steel pipe would be used to transport the brine from 4,000 feet to 12,000 feet from the collection sites to the disposal wells. Four injection wells with an average depth of 7,000 feet would be required for Area XIII, including the existing well presently in use on Jonah Creek. There would be two injection wells for Area XIV near the salt source on Salt Creek. The brine would be chemically treated and filtered as required, prior to injection. The following levels of chlorides removed were investigated: 115, 229, 347, and 462 tons per day, which relate to 1.4, 2.8, 4.3, and 6.5 c.f.s., respectively. The first three levels collect only from Jonah Creek, while the remaining level collects brine from both Jonah and Salt Creeks.

e. Plan E - Desalination. The collection system utilized for this plan is the subsurface cutoff system and is the same as that discussed in Plan A. After collection, the brine would be piped to a desalination plant near the salt sources about a mile north of the Prairie Dog Town Fork of the

Red River. After desalting, the product water would be pumped about one mile and returned to the Prairie Dog Town Fork of the Red River or put to some other beneficial use. The effluent would be pumped about 10½ miles to a brine impoundment dam at the Dry Salt Creek site for disposal.

f. Plan F - Shallow Well Collection and Brine Impoundment. The collection facility utilized for Plan F would be the shallow well system. The wells, spaced about 250 feet apart, would collect the brine at each principal salt emission area before the brine water flows to the surface or enters the alluvium. The objective is to construct enough shallow wells in each area to collect the amount of brine flow necessary to achieve various levels of control. Each of the wells would be drilled so that each pump would be five to ten feet into bedrock (about 40 to 45 feet for Area XIII and 35 to 40 feet for Area XIV). Each will be encased with a PVC liner. A submergible pump designed for corrosion resistance would be placed within the casing. The wells would have a PVC discharge pipe connected to a common header pipe. The header pipe would connect to the transmission pipe to transport the brine to the disposal system. The existing Jonah Creek subsurface collection system which pumps one c.f.s. is utilized in all levels of control for both collection and disposal systems developed for this plan. The disposal system other than the existing Jonah Creek facility would be the brine dam discussed in Plan A.

g. Plan G - Shallow Well Collection and Deep Well Injection. The collection system utilized for Plan G is the same as that described for Plan F. The existing collection system on Jonah Creek pumps its brine flow to an existing deep well for injection. This system is not considered in the cost estimates of Plan G, since it is a total system itself, but the 1.0 c.f.s. peak pump rate is considered an existing part of the new design and is allocated as collecting and disposing of 93 tons of chloride per day. The disposal system consists of the brine being pumped from the shallow well collection system to deep wells for injection into the Ellenburger Formation. PVC or PVC-lined standard steel pipe is used to transport the brine the 2,100 to 10,500 feet from the collection site to the disposal site. Average depth of the wells would be 7,000 feet. Depending on the level of control, there would be from one to five injection wells at Area XIII and XIV. Before injection into the wells, the brine would be treated as required. The chloride removal rates investigated are the same as for Plan D. Annual cost curves for the alternative plans are shown on Figure 6-3.

h. Plan H. The collection facility utilized for Plan H would be the shallow well system. The wells, spaced about 250 feet apart would collect the brine at each principal salt emission area before the brine water flows to the surface or enters the alluvium. The objective is to construct enough shallow wells in each area to collect the amount of brine flow necessary to achieve various levels of control. Each of the wells would be drilled to extend into the aquifer to the depth required for brine emission control (about 40 to 45 feet for Area XIII and 35 to 40 feet for Area XIV.) Each will be encased with a PVC liner. A submergible pump designed for corrosion resistance would be placed within the casing. The wells would have a PVC discharge pipe connected to a common header pipe. The header pipe would connect to the transmission pipe to transport the brine to the disposal system. The existing Jonah Creek subsurface collection system which pumps one c.f.s. is utilized in all levels of control for both collection and disposal systems developed for this plan. The disposal system other than the existing Jonah Creek would be the Crowell Brine Dam. The brine from the shallow well system would be transferred to a sump where it would be pumped with 1.0 c.f.s. brine flow from Area XV 30 miles to Area IX. A pipeline from Area IX to Crowell Brine Lake, 18 miles, would transfer flows from Areas IX, XIII, XIV, and XV. Pertinent data for Crowell Brine Lake will depend on the level of control selected at each of the contributing areas.

6.45 Alternative Plans for Area XV. Specific alternatives providing a total system for removal of chlorides from Area XV are discussed in the following subparagraphs. Cost curves for various levels of chlorides removed in tons per day (T/D) for the alternative plans are presented following the discussion of the alternatives. The average chloride load from Area XV is about 120 tons per day.

a. Plan A - Subsurface Collection and Brine Impoundment. The collection facility utilized for this plan was the subsurface cutoff system. There would be one subsurface system per salt source in Area XV. At the 29 T/D and 45 T/D levels of removal, there would be one subsurface system located near the Oxbow Creek site salt source (east location). At the 58 T/D and 73 T/D levels of removal, there would be one subsurface system near the Oxbow Creek site salt source and one near the Turkey Creek site salt source (west location). The brine would be collected in the filter bed and transferred by a feeder line to a sump. From the sump, the brine would be pumped 3,500 to 18,000 feet to the evaporation pond formed by the Oxbow Creek Dam at river mile 0.5. All pipe used would be PVC-lined standard steel pipe, except for the laterals in the streambed which are PVC only. The evaporation pond would have a surface area of from 1,000 to 1,400 acres and a dam length of from 6,000 to 7,500 feet, depending on the amount of chloride removed. Cost estimates were based on chlorides removed at four levels: 29, 45, 58, and 73 tons per day (T/D) which corresponds to 1.0, 1.7, 2.5, and 3.5 c.f.s. respectively. The 29 and 45 T/D removal plans collect brine from the east salt source and have one pump station each. The 58 and 73 T/D removal plans collect brine from both east and west salt sources and have two pump stations each. All pump stations would have backup pumps.

b. Plan B - Well Point Collection and Brine Impoundment. The collection system used for this plan was the well points. There would be six to sixteen well point collection systems located near each salt source. Each wellpoint system would consist of 215 wellpoints. The 29 T/D removal level would have six well point systems at the east salt source (Oxbow Creek area). The 45 T/D removal plan would have 10 well point systems at the east salt source. The 58 T/D removal plan would require 10 well point systems at the east and west salt sources (Turkey Creek area). The 73 T/D removal rate would require 16 well point systems at the east and west salt sources. In all plans, the brine would be collected from each system in the riverbed and delivered to a pump station near the river bank for transport by pipeline to the disposal system. All pipe utilized would be PVC-lined standard steel pipe, except for the laterals in the streambed which would be PVC only. The disposal system consists of the brine being pumped to the brine impoundment dam discussed in Plan A.

c. Plan C - Low Flow Dam Collection and Brine Impoundment. The collection system utilized for this plan is the low flow dam. There would be one low flow dam at the east salt source (Oxbow Creek) and one at the west salt source (Turkey Creek). The 29 and 45 T/D removal levels control the east salt source only, while the 58 and 73 T/D removal rates control both the east and west salt sources. After the brine is collected, it would be transported by pipeline to the disposal system. The disposal system consists of the brine being pumped to the impoundment dam at the Oxbow Creek site discussed in Plan A.

d. Plan D - Subsurface Collection and Deep Well Injection. The collection system utilized for this plan is the subsurface cutoff walls which were discussed in Plan A. The disposal system consists of the brine being pumped from the subsurface collection system to deep wells for injection into the Ellenberger formation. PVC-lined standard steel pipe would be used to transport the brine 3,300 to 5,800 feet from the collection site to the disposal site. The average depth of the wells would be 7,000 feet. There would be four injection wells near the Oxbow Creek salt source and four injection wells near the Turkey Creek salt source. The brine would be chemically treated and filtered before being injected into the wells.

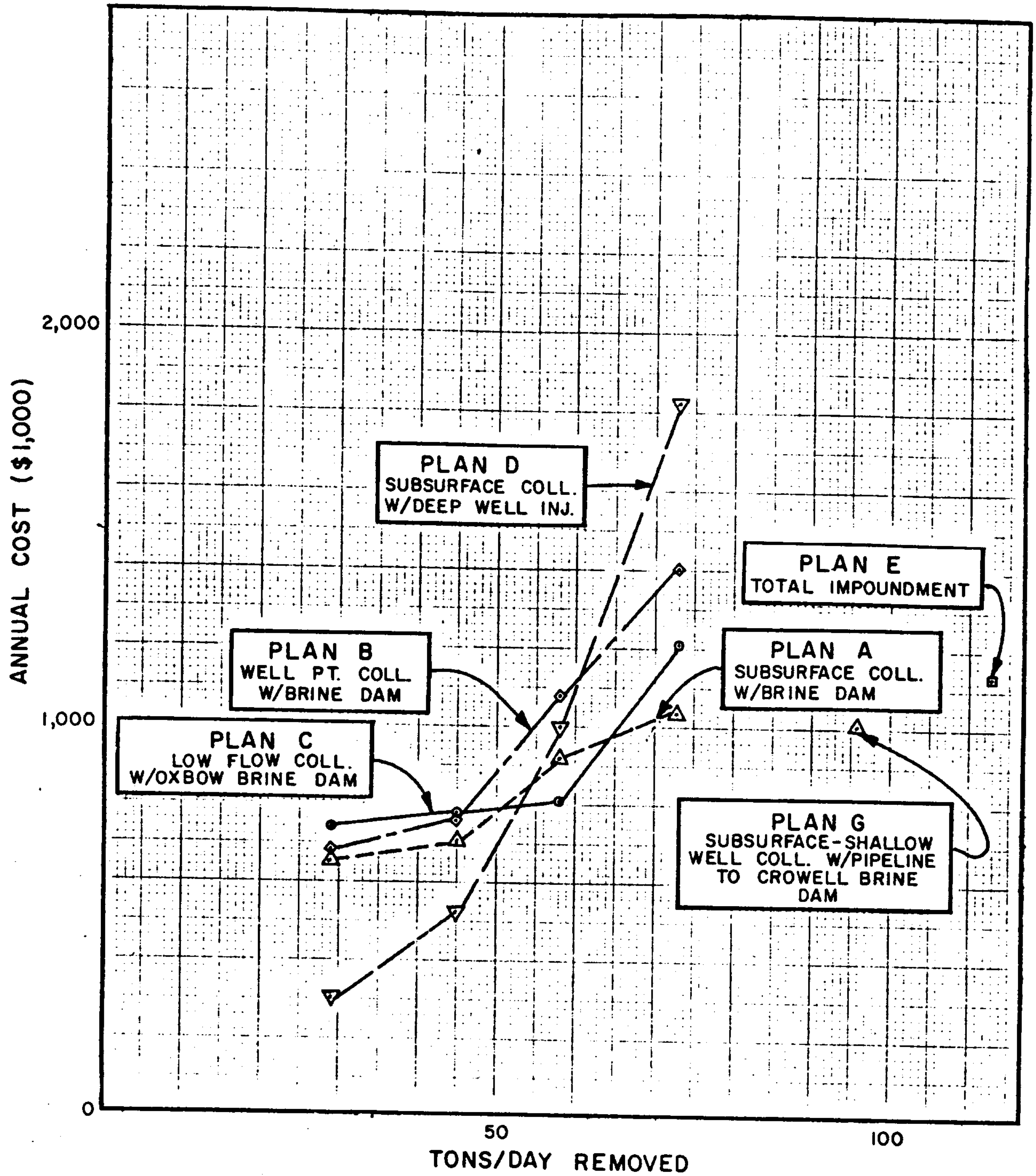
e. Plan E - Total Impoundment. Plan E consists of a total system for removal of chloride from Area XV. Total impoundment consists of a brine dam which would be located on the Little Red River approximately fourteen miles upstream from the junction of the Little Red and Prairie Dog Town Fork Rivers. The brine dam would provide for collection of the chlorides by the impoundment of the waters containing emissions from the two salt sources in Area XV. Disposal would consist of the chlorides settling to the lake bottom of the evaporation pond. The surface area of the brine lake would be 3,600 acres. The dam would have a length of 5,750 feet and a height of 116 feet, side slopes of 1:3, and a crown width of 20 feet.

f. Plan F - Desalination. The collection system utilized for this alternative was subsurface cutoff system discussed in Plan A. After collection, the brine is piped to a treatment plant near the Oxbow Creek damsite. After desalting, the product water would be pumped about three-quarters of a mile and returned, downstream of the salt source, to the

Little Red River. The disposal system consists of the effluent being pumped to a brine impoundment dam at the Oxbow Creek damsite at river mile 0.5. The evaporation lake and dam size would be approximately 10 percent smaller than the one utilized in Plan A.

6.46 <u>Plan G - Subsurface Cutoff Wall with Shallow Well Collection and Disposal at Crowell Brine Lake</u>. The collection facility utilized for this plan is a combination of the subsurface cutoff system and the shallow well system. Three separate collection areas would be utilized: Bluff Creek, Lost Mule Creek, and the main stem of Little Red River. The subsurface cutoff walls would be located at the mouths of Bluff and Lost Mule Creeks and upstream from the Highway 70 bridge on Little Red River. The shallow well system would be located immediately upstream from the subsurface cutoff walls. This collection system would provide 96 T/D removal. The collected brine from the three areas would be transferred by pipeline to a common sump. From the sump, the brine would be pumped approximately 36 miles to the Area XIII - XIV collection area where the flows would be combined and pumped to the Crowell Brine Lake where storage is available for final disposal. The wells for the shallow well system would be spaced about 250 feet apart and would collect the brine at the principal salt emission areas before the brine water flows to the surface or enters the alluvium. Each of the wells would be drilled so that each pump would be five to ten feet into bedrock. The submergible pumps are designed for corrosion resistance and placed in a PVC lined casing. The wells would have a PVC discharge pipe connected to a common header pipe. The header pipe would connect to the transmission pipe to transport the brine to the disposal system. The subsurface cutoff wall would be placed downstream from the shallow well system to collect brine flows in the alluvium and would be the same as described in Plan A.

6.47 <u>No Action</u>. Construction of collection and disposal systems for control of natural chloride emissions could be postponed indefinitely. The alternative of no development was an option that Congress had when the decision was made to authorize the Red River Chloride Control Project for the primary purpose of water quality improvement. This alternative does not prevent private or other public interests from constructing control measures at one or more emission areas, but for significant improvement of the water quality downstream, the salt areas must be controlled as a system. Development of a control plan for the system of source areas requires construction in two states with benefits spread over four states. No private organizations have shown interest in the task nor have any cooperative agreements among the four states been formed to confront the problem. Thus, if the alternative to forego Federal action were taken, it is probable that no other action would be taken to control the natural chloride emissions in the Red River Basin. The primary objective of the plan outlined in Senate Document No. 110, which is the basis for authorization of the Red River Chloride Control Project, was to improve the water quality in




AREA XV

Figure 6-4

the Red River Basin by control of natural chloride emissions. Omitting the control structures at the emission areas would forego the benefits of preventing damages to water users in the basin. Current and projected water use by agricultural, municipal, and industrial interests show an increased dependence on the Red River for the next one hundred years. With no control of the natural pollution sources, those users will incur damages to pipes and equipment, experience lower crop yields or grow lower value salt-tolerant crops, or be forced to construct expensive advanced treatment facilities.

6.48 Summary. The alternative studies can be summarized as follows:

a. General Alternatives. The general system alternatives of a pipeline to the Gulf of Mexico and importation of water for dilution purposes were screened from further study. The pipeline alternative had excessive project costs, a long period of construction, and the potential of adverse environmental effects on soil and water caused by deterioration or breaks in the pipeline. In addition, disposal of brines in the Gulf would have adverse effects on marine communities on the coast. The importation alternative was screened from further study because of excessive cost and because of political implications between states where no river compact has been consummated.

b. Specific Alternatives. Except for the following, all specific alternatives discussed in the preceding paragraphs were retained for further study. The desalination alternative for Areas VI, IX, XIII-XIV, and XV was screened, since the process would yield a brine effluent which would require a secondary disposal method. First costs and operating costs were not competitive with other alternatives. In addition, the plants must be replaced approximately every 20 years and operate in the general cost range of $1.00 per thousand gallons, according to the Office of Saline Waters Report, "Status of Desalting." In Area IX, Plan B, subsurface collection with deep well injection, and Plan E, total impoundment, were deleted from further study. Plan B was screened since no adequate subsurface formation for deep well injection was available near the area, and Plan E was screened because the elevation of the required pool would back brine waters into a poor geologic region which would result in brine leakage. The remaining alternatives were subjected to economic, environmental, and social effects investigations to determine the most acceptable alternative for each area.

(1) The selected plan for Area VI was Plan B. Plans A and C were eliminated because of their high cost. Plan D was less expensive than the selected plan at all levels of control and Plan F was less expensive at the upper levels of control. However, both of these plans were excluded because they included deep well injection. Some questions exist regarding brine disposal by deep well injection. Long-term projections of the storage capacity of the disposal zone are somewhat uncertain. Computations are based on conditions at the well bore and from exploratory wells drilled in the project vicinity. However, the geologic formations evaluated at the disposal zones may not be uniform over a wide areal extent.

(2) At Area IX Plan G was selected. Plans A, C, and D were eliminated because they offered no more benefits than Plan G and at a higher cost.

(3) At Areas XIII - XIV Plan H was selected. Plans D and G included deep well injection and were eliminated because of the high volume of flow and relatively low concentration of brine. In addition, high volume flow rates could exceed the estimated storage capacity of the subsurface formation within the proposed project life. Plans A, B, C, and F were more expensive than Plan H without offering any additional benefits and were thus eliminated.

(4) Optimization studies were conducted with the recommended plan at each area to determine the overall plan and level of control that would yield the maximum economic benefits. These studies showed that development of Area XV is not incrementally justified at this time. The final plan selection made substantially satisfies the water quality objectives set forth in the authorizing documents.

c. Selected Plan. The alternatives for each area shown below comprise the selected plan:

| Area | Alternative | Collection System | Disposal System |
|---|---|---|---|
| VI | B | Subsurface w/supplemental brine pickup | Fish Creek Brine Dam |
| IX (1) | G | Shallow wells | Crowell Brine Dam |
| XIII-XIV | H | Shallow wells | Crowell Brine Dam |
| XV (1) | G | Subsurface w/shallow wells | Crowell Brine Dam |

(1) Area XV and the North Pease River of Area IX are recommended for future development.

## SECTION 7

## THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

7.01 These projects are proposed in the interest of maintenance and, especially, enhancement of long-term productivity. The land is currently used for livestock production and to a lesser extent for farming. Without the project, the land use of the surrounding areas will remain about the same. The projects would provide stream water quality below the low flow dams that would be acceptable for livestock drinking water and for irrigation uses. The brine storage lakes may provide a limited source of water-oriented recreation facilities in an area that is now deficient in this respect. The projects will aid in the abatement of natural mineral pollution of waters of the Red River Basin by reducing the chloride concentrations to a level acceptable for municipal, industrial, and agricultural uses. There will be a reduction in wildlife habitat as the brine lakes fill and public use of the area increases. Over the long term, the minnow fishery probably will remain about the same as it is now.

## SECTION 8

### IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED

8.01 The reduction of flows entering Lake Kemp is estimated to be about 7 percent of the average daily flows entering the lake. Improvement of water quality downstream should encourage downstream withdrawals. Downstream aquatic habitat should be improved because of better water quality.

8.02 The project will degrade water quality in the part of the drainage basins utilized as brine lakes. The brines will be transferred into an area where the surface waters are not highly saline and the brines will become highly concentrated by evaporation. About 11,190 acres eventually will be covered with brine. The sedimentation rates may increase as the lakes fill because the rate of erosion in the drainage area adjacent to the lakes probably will increase as a result of short-term fluctuation of the water level.

8.03 The proposed project will convert about 18,900 acres of land in fee and 1,760 acres in easement from private ownership to public ownership. Some relocations of roads and structures will be necessary.

8.04 Wildlife habitat for species such as dove, cottontail rabbit, scaled and bobwhite quail will be lost. About 3,424 acres of woodland vegetation at the Crowell Brine Lake site and approximately 2,109 acres of juniper scrub vegetation at the Truscott Brine Lake site will be lost to construction activities and project operation. Slightly more than one-half of the area of the project sites which now provide food and cover for wildlife will be lost. The remaining wildlife habitat will vary in quality depending upon recreational development.

8.05 There is the possibility of loss of some archeological and paleontological sites if the project is implemented without first executing a more thorough investigation and salvage. All lands inundated by low-flow and brine collection lakes will be permanently lost to future use because of salt contamination. There may be some mineral reclamation and temporary use by migrating waterfowl. Some livestock production grazing areas and wildlife habitat will be lost.

8.06 Labor, capital, land and energy required for construction and operation of the project will be irretrievably committed.

## SECTION 9 - COORDINATION AND COMMENT AND RESPONSE

9.01 Public Participation. Public meetings were held at Childress, Texas (5 November 1969), Lawton, Oklahoma (3 December 1964) and Wichita Falls, Texas (26 September 1972) for public discussion of the Red River Chloride Control project. Planning workshops in addition to the public meetings were more recently conducted at Mangum, Oklahoma, Childress, Vernon, Denison, Wichita Falls, Texas, and Shreveport, Louisiana, during August and September, 1974. The purpose of each workshop was to provide persons from the local area with information regarding the Corps water resources study in the Red River Basin. In addition, public opinion with regard to the project and control alternatives was solicited through the means of questionnaires. Individuals in attendance received information on the study background, sources of natural salt, and alternative control plans. No unresolved conflicts arose as a result of the workshops.

9.02 Agencies, Groups, and Individuals. Pursuant to provisions of the National Environmental Policy Act of 1969 (Public Law 91-190), coordination has been conducted with agencies which are authorized to develop and/or enforce environmental standards to obtain a current assessment of the environmental impact of the proposed plan. Interested citizen groups also were invited to comment on the environmental impacts involved in implementing the Red River Chloride Control project.

9.03 Comments were received from:

Federal Agencies

Advisory Council on Historic Preservation
Department of Transportation (Oklahoma)
Department of Health, Education and Welfare
US Department of Commerce
Department of Housing and Urban Development
Department of Transportation (Texas)
Soil Conservation Service
US Forest Service
Department of the Interior
Environmental Protection Agency

State Agencies

Oklahoma Department of Wildlife Conservation
State Grant-In-Aid Clearinghouse (Oklahoma)
Oklahoma Archeological Survey
Oklahoma Historical Society
Texas Department of Health Resources
Texas Water Quality Board
Texas Parks and Wildlife Department

9.03a Comments were requested but not received from the following:

Federal Energy Administration
Rare Plant Study Center, University of Texas
Oklahoma Conservation Commission
Oklahoma Water, Inc.
Texas Historic Preservation Officer
Center for Urban Affairs, Northwestern University, Evanston, Illinois
Institute for Ecological Studies, University of North Dakota, Grand Forks, North Dakota
Environment Information Center, New York City, NY
Institute for Environmental Studies, St. Louis University, St. Louis, Missouri
Wildlife Management Institute
Sierra Club, Oklahoma Chapter
Sierra Club, Texas Chapter
Scenic Rivers Association of Oklahoma
Oklahoma Wildlife Federation
Oklahoma Academy of Science
American Fisheries Society - Oklahoma Chapter
Tulsa Audubon Society
Oklahoma State University Library
Oklahoma University Library
Commission on Natural Resources, National Research Council, Wash DC
Izaak Walton League of America, Inc.
Coalition on American Rivers
Sportsmen's Clubs of Texas, Inc.
Texas Instruments, Inc.
Dr. Richard Sullivan
Mrs. Connie Taylor
US Senator Henry Bellmon, Oklahoma
US Senator John Tower, Texas

Comment and Response

9.04 The draft statement was sent to the above listed agencies and groups requesting their review and comments. The comments which were received are summarized in this section with responses to those comments, and copies of their original replies are in Appendix A. Other agencies and groups which did not reply to the draft within the 45-day waiting period were assumed to have no comments or objections to the project.

Advisory Council on Historic Preservation

9.05 COMMENT. Pursuant to its responsibilities under Section 102(2)(C) of the National Environmental Policy Act of 1969, the Advisory Council has determined that the DES appears adequate concerning compliance with Section 106 of the National Historic Preservation Act of 1966. We further note that while the DES does not demonstrate adequate compliance with Executive Order 11593, "Protection and Enhancement of the Cultural Environment" of May 13, 1971, it appears the Corps of Engineers is fully aware of the requirements of the Order and will take the appropriate steps for compliance prior to proceeding with the undertaking.

RESPONSE. Comment noted.

US Department of Transportation (Oklahoma)

9.06 COMMENT. Our review indicates that the proposal will have no significant impact on the transportation system in Oklahoma. As a result, we have no specific comment to offer on any of these documents.

RESPONSE. Comment noted.

Department of Health, Education, and Welfare

9.07 COMMENT. Accordingly, our review of the Draft Environmental Statement for the project discerns no adverse effects that might be of significance where our program responsibilities and standards pertain, provided that appropriate guides are followed in concert with State, County, and local environmental laws and regulations.

RESPONSE. Comment noted.

United States Department of Commerce

9.08 COMMENT. Bench marks, triangulation stations, and traverse stations have been established by the National Geodetic Survey in the vicinity of the proposed project. Construction required for the project could result in destruction or damage to some of these monuments.

RESPONSE. To our knowledge, no National Geodetic Survey monuments will be affected by the project. If such is not the case, then the National Geodetic Survey will be notified.

9.09 COMMENT. The National Geodetic Survey requires sufficient advance notification of impending disturbance or destruction of monuments so that plans can be made for their relocation. It is recommended that provision be made in the project funding to cover costs of monument relocation.

RESPONSE. Comment noted. See above response.

Department of Housing and Urban Development

9.10 COMMENT. The Department of Housing and Urban Development has reviewed the Draft Environmental Statement on Red River Chloride Control Water Quality Study, Red River, Texas and Oklahoma, and does not have comments on the subject Statement or project.

RESPONSE. Comment noted.

US Department of Transportation (Texas)

9.11 COMMENT. We have no comments to offer on the proposed project.

RESPONSE. Comment noted.

United States Department of Agriculture
Soil Conservation Service

9.12 COMMENT. Paragraph 2.37 refers to work by Blair. However, the section on vegetation (pages 2-7 through 2-17) does not appear to follow his work. The section on vegetation is not consistent with Blair in describing the vegetation assemblages found in the project area.

RESPONSE. The section on vegetation does not follow the work of Blair. The discussion is based on a field survey and inventory of plants in the project areas by West Texas State University, Canyon. The reference to Blair (1950) is to denote the general biotic district in which the project areas are located.

9.13 COMMENT. The use of the term "woodland" for vegetation in the areas of this project is misleading. The term "shrub" and "brush" would appear to be more descriptive of the woody species.

RESPONSE. The term "woodland" is used in the report by West Texas State University to describe the major vegetation types in the study area and, while it is not meant to be misleading, we don't feel that we should change it; however, we have clarified what is meant by "woodlands" in paragraph 2.53.

9.14 COMMENT. Paragraph 2.43 refers to a vegetation map which is not included in the environmental impact statement.

RESPONSE. This has been corrected.

9.15 COMMENT. Paragraph 2.44 is not clear as to what area is being described. It appears that it may refer to Area V.

RESPONSE. The area being described is the Truscott Brine Lake Area, and this is now shown in paragraph 2.52.

9.16 COMMENT. Common plant names used are not identified by scientific names. Several names of plants such as pea-bush, reed-grass, etc., are difficult to ascertain as to their identity in Appendix B.

RESPONSE. Scientific names are not included in the narrative for the sake of simplicity. Appendix B has been deleted from the final environmental statement.

9.17 COMMENT. Paragraph 2.39 contains a statement that the area occupied by a certain vegetative type has little agricultural value. This should be clarified to indicate its value for grazing.

RESPONSE. A field study of the vegetation in the area was conducted by West Texas State University. If the area had been of great value for grazing or any other agricultural activity, this would have been brought out in the environmental statement.

9.18 COMMENT. The reference source for range sites under vegetation could be cited.

RESPONSE. This information was taken from a report prepared by West Texas State University for the Tulsa District titled Environmental Inventory and Assessment: Areas VI, IX, XIII, XIV, and XV, Red River, Chloride Control Project, Oklahoma and Texas.

9.19 COMMENT. Section 8, paragraph 8.03, indicates that 13,710 acres of land will be converted from private ownership to public ownership by fee and another 1,150 acres will be converted by easement. There is no indication in this section or under impacts of the number of operating units (farm and/or ranch) that will be affected.

RESPONSE. Approximately 70 ownerships will be affected. As of now, 18,900 acres of land will be converted from private ownership to public ownership by fee and 1,760 acres will be bought in easement.

United States Department of Agriculture
Forest Service

9.20 COMMENT. The draft statement does not disclose anticipated project impacts on tree plantings for windbreaks, soil erosion control, etc., within the project area. How many acres of this extremely valuable use will be directly or indirectly impacted by the project? What will be the long term productivity loss incurred by such action?

RESPONSE. A field study in the project areas was conducted by West Texas State University for the Tulsa District. Their report did not mention any areas where windbreaks will be disturbed and to our knowledge none will be affected by the project. Soil erosion control methods will be utilized in areas where construction will occur.

9.21 COMMENT. Table 2.2 lists two endangered plant species, *Eriogonum correllii* and *Morus microphylla*. However, on page 4-10, the statement is made that the one endangered plant species in the project area is *Eriogonum correllii*. What is the estimated population and range of *Morus microphylla*?

RESPONSE. We do not know the estimated population or range of *Morus microphylla*, but if this species were to have been affected by the project, it would be discussed in the environmental statement.

9.22 COMMENT. Project proposals for the protection of endangered plant species need amplification. The statement is made (page 4-10) that *Eriogonum correllii* is endemic to the Texas Panhandle and has been reported from only five localities. What are the known populations in the five localities? Is the plant plentiful enough to take a chance on it being receptive to transplanting elsewhere, if need be?

RESPONSE. We do not know the estimated populations in the five localities. Only one of the localities could be affected by the project, and it is believed that the species will be receptive to transplanting elsewhere if necessary.

United States Environmental Protection Agency
Region VI

9.23 COMMENT. Paragraph 4.05, page 4-9, notes, "degradation of soils ~~not covered by lake waters is a probability~~ if waters are withdrawn ~~from~~ the brine lakes for agricultural purposes." Although information is available about the tolerance of various crops to salinity levels, the statement notes, "Use of these saline waters for any irrigation purpose, however, will be at the expense of the general productivity of the soil." We suggest that a water quality monitoring program be implemented to measure salinity levels if the waters from the brine lakes are ever used for the irrigation of crops. Such a program would be beneficial in assuring that the long term general productivity of the area soils is maintained.

RESPONSE. There are no provisions for using the brine for irrigation. Landowners will be knowledgable of the brine lake's water quality and the probability of its use for future irrigation use will be remote. Groundwater conditions in the brine lake vicinity will be monitored prior to and after construction.

9.24 COMMENT. On page 4-12, paragraph 4.08 states, "Several relocations of negligible environmental proportions will be required by the project. These include county roads, pipelines, and ranch structures." The number of each type facility to be relocated and the extent (length of pipeline displaced, etc.) of the relocations need to be described. Also, the parties responsible for the various relocations should be identified.

RESPONSE. About 2.1 miles of 13.2 kv powerline would have to be removed and replaced with about 5.0 miles of powerline relocation at Crowell Brine Lake. About 1.0 mile of county road relocation would be required. No pipelines will have to be relocated.

About 2.2 miles of 7.2 kv powerline would have to be removed and replaced with about 3.6 miles of powerline at Truscott Brine Lake. About 4.0 miles of county road relocation would be required.

The contractor who is awarded the job will be responsible for relocation.

9.25 COMMENT. With regard to secondary environmental impacts of the project, on page 4-12 it is noted that in the region (Lake Texoma and the upstream highly-saline tributaries of the Red River) the availability of better quality water may encourage people to move into the area and may slow down the migration trends out of the area. As a result of this anticipated regional growth, we suggest that potentially adverse secondary effects, such as increased noise, solid waste, air and water pollution, be fully discussed in the statement.

RESPONSE. This has been included in Section 4, Impacts of Project Purposes on Region.

9.26 COMMENT. Under paragraph 4.12, Project Impacts on Historical and Archeological Sites, paleontological information is mentioned. Paleontological considerations should be included under Geology, pages 2-1 to 2-3, rather than under 4.12.

RESPONSE. Comment noted.

United States Department of the Interior

9.27 COMMENT. PROJECT DESCRIPTION - During the development of a fish and wildlife report to accompany the Corps' Phase I GDM, the Fish and Wildlife

Service was unofficially informed that project lands at the three brine pool areas would be fenced and marked at project cost. If this is correct, it should be so indicated in this section of the statement. Many of the potential beneficial impacts discussed in Section 4 of the statement regarding public access to and use of project lands for recreation would not be likely without the fencing and marking of these lands.

RESPONSE. This is correct and is discussed in the narrative in Section 1 and as a project cost in Section 1.

9.28 COMMENT. ENVIRONMENTAL SETTING WITHOUT THE PROJECT - Page 2-6. Paragraphs 2.29 and 2.30. The data furnished are not adequate for appraisal of specific ground water impacts. The text indicates that shallow aquifers are variously distributed and not areally of great extent, and a few general details on the occurrence of fresh ground water are given, but these are inadequate for evaluation of impacts. The statement should indicate more specifically the types of spatial and hydraulic relationships that will exist between the proposed saline water impoundments and adjacent fresh water aquifers, springs, and wells. The statement should also highlight any plans or proposals which may be used to minimize chances for further deterioration of potable ground water.

RESPONSE. A ground water resources survey has been accomplished although the available data are rather sketchy. A more detailed effort is required to determine spatial and hydraulic relationships between groundwater sources and the proposed impoundments. Groundwater conditions will be monitored prior to and after construction.

9.29 COMMENT. Pages 2-18 and 2-20. Paragraphs 2.81 and 2.91. In order to avoid confusion, it would be well to indicate that the mammals and birds listed as endangered species in these paragraphs are officially listed on the United States List of Endangered Fauna, pursuant to the Endangered Species Act of 1973.

RESPONSE. This has been done.

9.30 COMMENT. Page 2-25. Paragraph 2.104. The potential Natural Landmark of Estelline Salt Springs, which is now being evaluated by Dr. David Northington of Texas Tech at Lubbock for the National Park Service, lies along the collection pipeline proposed for future development between collection area XV and XIII. The Estelline site may be significant for a relict species of crab that has been extirpated by other work in this area.

RESPONSE. Comment noted.

9.31 COMMENT. PROBABLE IMPACT OF THE PROPOSED ACTION ON THE ENVIRONMENT - Page 4-1. Paragraph 4.01. It is recognized in the statement that the proposed action will degrade rather than enhance water quality in parts of the drainage basin utilized as brine lakes. Any mitigating measures that may be used to minimize this impact should be discussed.

RESPONSE. Mitigation is discussed in Section 1. The water quality in the impounded reach will continue to degrade with time as the dams are total retention structures. Fresh water to dilute and improve this concentrated brine water isn't available; however, field reconnaissance work and studies indicate the labeled areas have relatively impervious formations to prevent contamination of the ground water. Extensive subsurface exploration, including core borings and pressure testing are planned before brine is impounded and in addition, groundwater conditions will be monitored prior to and after construction.

9.32 COMMENT. Page 4-7. Paragraph 4.02. It is indicated in the statement that increased lake sedimentation will occur as a result of bank erosion especially along segments of banks where gypsiferous stringers are associated with soft shales. Any mitigating measures that may be used to minimize this impact should be included.

RESPONSE. The lakes are designed to allow for lake sediment deposits over the project life. Due to the large lake areas involved, only the critical areas such as high banks could be economically stabilized. In critical areas, soil cement would provide slope protection. Sand is present in the area for soil cement.

9.33 COMMENT. Page 4-13. Paragraph 4.10. This section indicates that the new water area may be important as a recreation water site because water is short in the region. Even though the evaporation lakes can be expected to expand to a size adequate for water-oriented recreation activities, water quality could be a significant issue affecting recreational use. This aspect should be more fully addressed in the statement.

RESPONSE. It is brought out in paragraph 4.10 that the salinity of the water in the brine lakes will affect recreational use of the lakes. We feel that the discussion in paragraph 4.10 is adequate in addressing this issue.

9.34 COMMENT. Page 4-15. Paragraphs 4.16 and 4.17. These paragraphs state that the project is likely to stimulate industrial, residential, and agricultural growth throughout the basin. Changes such as these generally are not compatible with maintaining fish and wildlife production on land and water areas now suitable for such uses. Section 4 should also address the adverse secondary impacts of the project on fish and wildlife populations that result from the expected land and water use changes associated with industrial, residential, and agricultural growth.

RESPONSE. A discussion of possible secondary impacts on fish and wildlife has been added to paragraphs 4.13 and 4.14.

9.35 COMMENT. Page 5-1. Paragraph 5.03. The animals displaced by inundation of habitat in the brine lakes cannot realistically be expected to survive. Surrounding habitat on uplands and escarpments normally will be at or near its carrying capacity and could not support additional wildlife populations for any length of time.

RESPONSE. A statement to this effect has been added to Section 5.

9.36 COMMENT. Page 5-3. Paragraph 5.05. Brief mention is made of archeological sites in this paragraph. It would seem appropriate to expand the discussion of probable adverse environmental effects on archeological resources under a separate heading.

RESPONSE. Archeological investigations have been largely of a reconnaissance nature up to this time. Enough study has been done to indicate where additional work must be done. The archeological survey revealed nothing that would require alteration of construction plans, but did indicate several potentially important sites that warrant further investigation and possibly salvage prior to implementation of the project. Until further investigations are done, there is no point in expanding the discussion of archeological impacts.

Department of Wildlife Conservation

9.37 COMMENT. We have reviewed the draft and have no comment in that regard.

RESPONSE. Comment noted.

State of Oklahoma
State Grant-In-Aid Clearinghouse

9.38 COMMENT. The state agencies, comprising the Pollution Control Coordinating Board, have reviewed the proposed project. A copy of the comments of Oklahoma Archaeological Survey is attached and made a part of this letter. The state clearinghouse requires no further review.

RESPONSE. Comment noted.

Oklahoma Archaeological Survey

9.39 COMMENT. We have reviewed the above referenced EIS with reference to cultural and historical sites, which may be affected by the project. It is indicated that while a cursory examination of the project areas have been made; the probability of adverse affect exists. However, the actual on-site survey will not be made till January of 1976. Although such a survey is planned and includes a statement indicating intent to follow up with a mitigation plan, if necessary, I question the filing of an EIS that has not yet taken these things into consideration.

While we do not oppose the projects intent, we do request the Corps account for the total affect the project will have on cultural resources in the project area. At this time it does not appear the Corps has included such consideration or done the necessary field work to do such consideration.

RESPONSE. The results of a more detailed survey and mitigation plans will be added as a supplement to the final environmental statement after it has been filed. The supplement will take into account the total effect the project will have on cultural resources.

Oklahoma Historical Society

9.40 COMMENT. It appears that "Jaybuckle Spring," on Elm Creek due north of Reed will be affected by your plans for Area VI, collection pool, Greer County, Oklahoma. No other Oklahoma listed sites appear to be affected.

Although this site is not on the National Register of Historic Places, it is considered a local landmark and was once the headquarters area of an early-day cattle company.

RESPONSE. We have investigated and determined that Jaybuckle Spring will not be affected by the project.

Texas Department of Health Resources

9.41 COMMENT. There are several public water supplies which use surface water sources in the Project Area. No adverse effects on these public water systems are expected to occur as a result of the construction of the proposed brine emission correction facilities. The reduction of the existing natural chloride concentration of waters of the Red River Basin to a level acceptable for municipal, industrial and agricultural uses is considered to be a desirable objective.

RESPONSE. Comments noted.

Texas Water Quality Board

9.42 COMMENT. The staff of the Texas Water Quality Board has reviewed the draft environmental impact statement for the Red River Chloride Control Water Quality Study of the Red River Basin and concurs with the findings regarding water quality in the basin under both the present conditions and also under the projected future conditions with the proposed developments installed or constructed.

RESPONSE. Comments noted.

Texas Parks and Wildlife Department

9.43 COMMENT. In Section 5, paragraph 5.03 Wildlife Habitat, the statement is made: "Adequate food and cover for the displaced animals will probably be provided by the vegetation of the escarpments and uplands." It is suggested that if the carrying capacity of the adjacent escarpments and uplands is such that it would sustain the population of wildlife which would be added as a result of displacement, such populations would already exist. The displacement of wildlife from the stream beds and reservoir sites onto the adjacent escarpments and uplands will place additional pressure on those food and cover resources to the point of their being over-utilized, thereby resulting in increased deterioration of the habitat and eventual loss of the wildlife.

RESPONSE. This statement has been changed to read as you suggest.

9.44 COMMENT. It is also noted that some wildlife habitat will be permanently lost due to construction activities and inundation. This Department feels that some indirect mitigation for these losses may be gained if the impoundment sites were fenced. It is noted that there is no mention of fencing the brine pools in the document. It is suggested that such activity would render the project more acceptable. This is particularly true if any enhancement projects are undertaken in the future.

RESPONSE. Mitigation is discussed in Section 1.

## APPENDIX A

## CORRESPONDENCE

Advisory Council
On Historic Preservation
1522 K Street N.W.
Washington, D.C. 20005

September 18, 1975

Mr. Weldon M. Gamel
Chief, Engineering Division
Corps of Engineers, Tulsa District
Department of the Army
P. O. Box 61
Tulsa, Oklahoma 74102

Dear Mr. Gamel:

This is in response to your request of September 12, 1975 for comments on the draft environmental statement (DES) for Red River Chloride Control Water Quality Study, Red River, Texas and Oklahoma. Pursuant to its responsibilities under Section 102(2)(C) of the National Environmental Policy Act of 1969, the Advisory Council has determined that the DES appears adequate concerning compliance with Section 106 of the National Historic Preservation Act of 1966. We further note that while the DES does not demonstrate adequate compliance with Executive Order 11593, "Protection and Enhancement of the Cultural Environment" of May 13, 1971, it appears the Corps of Engineers is fully aware of the requirements of the Order and will take the appropriate steps for compliance prior to proceeding with the undertaking. Accordingly, we look forward to working with the Corps pursuant to the "Procedures for the Protection of Historic and Cultural Properties" (36 C.F.R. Part 800) at the appropriate time.

Should you have questions or require additional assistance in this matter, please contact Michael H. Bureman of the Advisory Council staff at P. O. Box 25085, Denver, Colorado 80225, telephone number (303) 234-4946. Your continued cooperation is appreciated.

Sincerely yours,

Louis S. Wall

Louis S. Wall
Assistant Director, Office
of Review and Compliance



*The Council is an independent unit of the Executive Branch of the Federal Government charged by the Act of October 15, 1966 to advise the President and Congress in the field of Historic Preservation.*

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
REGION SIX
Oklahoma City, Oklahoma 73103
October 9, 1975

IN REPLY REFER TO 06-40.6

Mr. Weldon M. Gamel
Chief, Engineering Division
Tulsa District, Corps of Engineers
P.O. Box 61
Tulsa, Oklahoma 74102

Dear Mr. Gamel:

This office has reviewed the draft environmental impact statement regarding the Red River Chloride Control Water Study, Red River, Texas and Oklahoma. We have also reviewed the draft copy of Volume I and Volume II of your Design Memorandum No. 25 prepared for the proposed project.

Our review indicates that the proposal will have no significant impact on the transportation system in Oklahoma. As a result, we have no specific comment to offer on any of these documents.

We appreciate the opportunity to review the documents.

Sincerely yours,

Frank N. Cunningham
for Gordon E. Penney
Division Administrator

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
REGIONAL OFFICE
1114 COMMERCE STREET
DALLAS, TEXAS 75202

OFFICE OF
THE REGIONAL DIRECTOR

Our Reference: EI# 0176-616

Mr. Weldon M. Gamel, Chief, Eng. Div.
Department of the Army
Tulsa District, Corps of Engineers
P. O. Box 61
Tulsa, Oklahoma 75202

RE: Red River Chloride Control
Water Quality Study

Dear Mr. Gamel:

Pursuant to your request, we have reviewed the Environmental Impact Statement for the above project proposal in accordance with Section 102(2) (c) of P. L. 91-190, and the Council on Environmental Quality Guidelines of April 23, 1971.

Environmental health program responsibilities and standards of the Department of Health, Education, and Welfare include those vested with the United States Public Health Service and the Facilities Engineering and Construction Agency. The U. S. Public Health Service has those programs of the Federal Food and Drug Administration, which include the National Institute of Occupational Safety and Health and the Bureau of Community Environmental Management (housing, injury control, recreational health and insect and rodent control).

Accordingly, our review of the Draft Environmental Statement for the project discerns no adverse effects that might be of significance where our program responsibilities and standards pertain, provided that appropriate guides are followed in concert with State, County, and local environmental laws and regulations.

We, therefore, have no objection to the authorization of this project insofar as our interests and responsibilities are concerned.

Very truly yours,

William F. Crawford

William F. Crawford
Regional Environmental Officer

EHS 10E



DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

**Reaction Review and Comments on Environmental Impact Statement for Project Proposal:**

**Draft Environmental Impact Statement** <u>Reviewed with Objections</u> ☐

**Draft Environmental Impact Statement** <u>Reviewed with No Objections</u> X

**Date:** October 21, 1975 **EI#** 0176-671

**Agency/Bureau:** DHEW/PHS

**Project Proposal:** Red River Chloride Control Project
Red River Texas and Oklahoma

**Comments:**

**UNITED STATES DEPARTMENT OF COMMERCE**
**The Assistant Secretary for Science and Technology**
Washington, D.C. 20230

October 23, 1975

Mr. Weldon M. Gamel
Tulsa District, Corps of Engineers
Department of the Army
Post Office Box 61
Tulsa, Oklahoma 74102

Dear Mr. Gamel:

The draft environmental impact statement "Red River Chloride Control, Water Quality Study, Red River, Texas and Oklahoma", which accompanied your letter of September 12, 1975, has been received by the Department of Commerce for review and comment. The statement has been reviewed and the following comments are offered for your consideration.

Bench marks, triangulation stations, and traverse stations have been established by the National Geodetic Survey in the vicinity of the proposed project. Construction required for the project could result in destruction or damage to some of these monuments.

The National Geodetic Survey requires sufficient advance notification of impending disturbance or destruction of monuments so that plans can be made for their relocation. It is recommended that provision be made in the project funding to cover costs of monument relocation.

Thank you for giving us an opportunity to provide these comments, which we hope will be of assistance to you. We would appreciate receiving five copies of the final statement.

Sincerely,

Sidney R. Galler

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
REGIONAL OFFICE
1100 COMMERCE STREET
DALLAS, TEXAS 75202

October 23, 1975

REGION VI

IN REPLY REFER TO:

6C

Your Reference:
SWTED-PE

Weldon M. Gamel
Chief, Engineering Division
Tulsa District, Corps of Engineers
Department of the Army
Post Office Box 61
Tulsa, Oklahoma 74102

Dear Mr. Gamel:

The Department of Housing and Urban Development has reviewed the Draft Environmental Statement on Red River Chloride Control Water Quality Study, Red River, Texas and Oklahoma, and does not have comments on the subject Statement or project.

Sincerely,

Travis Wm. Miller

Travis Wm. Miller
Environmental Clearance Officer



AREA OFFICES
DALLAS, TEXAS • LITTLE ROCK, ARKANSAS • NEW ORLEANS, LOUISIANA • OKLAHOMA CITY, OKLAHOMA • SAN ANTONIO, TEXAS
Insuring Offices
Albuquerque, New Mexico • Fort Worth, Texas • Houston, Texas • Lubbock, Texas • Shreveport, Louisiana • Tulsa, Oklahoma

E R

**U.S. DEPARTMENT OF TRANSPORTATION**
FEDERAL HIGHWAY ADMINISTRATION
826 FEDERAL OFFICE BUILDING
AUSTIN, TEXAS 78701

October 29, 1975

IN REPLY REFER TO

06-48.10A

Draft Environmental Statement
Corps of Engineers
Red River Chloride Control Water
Quality Study
Red River, Texas and Oklahoma

Mr. Weldon M. Gamel
Chief, Engineering Division
Department of the Army
Tulsa District, Corps of Engineers
P. O. Box 61
Tulsa, Oklahoma 74102

Dear Mr. Gamel:

Your letter of September 12, 1975, transmitted a draft environmental impact statement on the above project.

We have no comments to offer on the proposed project.

Sincerely yours,

George H. Nelson

FOR John J. Conrado
Division Administrator

ER

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
P. O. Box 648
Temple, Texas 76501

October 31, 1975

Mr. Weldon M. Gamel, Chief
Engineering Division
Corps of Engineers
Department of the Army
Post Office Box 61
Tulsa, Oklahoma 74102

Dear Mr. Gamel:

We have reviewed the draft environmental impact statement for the Red River Chloride Control Water Quality Study, Red River, Texas and Oklahoma.

The proposed project will provide for much needed improvement of surface water in the Red River Basin. The draft environmental impact statement adequately reflects the impacts that this improvement will have for the water users and the economy. However, we believe that the section on description of the vegetation of the area and the impacts of the installation of the brine lakes and storage areas on farm and ranch units could be improved. The following comments are submitted for your consideration:

1. Paragraph 2.37 refers to work by Blair. However, the section on vegetation (pages 2-7 through 2-17) does not appear to follow his work. The section on vegetation is not consistent with Blair in describing the vegetation assemblages found in the project area.

2. The use of the term "woodland" for vegetation in the areas of this project is misleading. The term "shrub" and "brush" would appear to be more descriptive of the woody species.

3. Paragraph 2.43 refers to a vegetation map which is not included in the environmental impact statement.

4. Paragraph 2.44 is not clear as to what area is being described. It appears that it may refer to Area V.

5. Common plant names used are not identified by scientific names. Several names of plants such as pea-bush, reed-grass, etc., are difficult to ascertain as to their identity in Appendix B.

6. Paragraph 2.39 contains a statement that the area occupied by a certain vegetative type has little agricultural value. This should be clarified to indicate its value for grazing.

7. The reference source for range sites under vegetation could be cited.

8. Section 8, paragraph 8.03, indicates that 13,710 acres of land will be converted from private ownership to public ownership by fee and another 1,150 acres will be converted by easement. There is no indication in this section or under impacts of the number of operating units (farm and/or ranch) that will be affected.

We appreciate the opportunity to review this draft and make appropriate comments.

Sincerely,

R. D. Swenson Acting

Edward E. Thomas
State Conservationist

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Southeastern Area, State and Private Forestry
1720 Peachtree Road, N.W.
Atlanta, Georgia 30309

Red River

8420
November 3, 1975

Mr. Weldon M. Gamel
Department of the Army
Post Office Box 61
Tulsa, Oklahoma 74102

Dear Mr. Gamel:

Here are United States Forest Service, State and Private Forestry comments on the draft environmental statement entitled, "Red River Chloride Control Water Quality Study, Red River, Texas and Oklahoma."

The draft statement does not disclose anticipated project impacts on tree plantings for windbreaks, soil erosion control, etc., within the project area. How many acres of this extremely valuable use will be directly or indirectly impacted by the project? What will be the long term productivity loss incurred by such action?

Table 2.2 lists two endangered plant species, Eriogonum Correllii and Morus Microphylla. However, on page 4-10, the statement is made that the one endangered plant species in the project area is Eriogonum Correllii. What is the estimated population and range of Morus Microphylla?

Project proposals for the protection of endangered plant species need amplification. The statement is made (page 4-10) that Eriogonum Correllii is endemic to the Texas Panhandle and has been reported from only five localities. What are the known populations in the five localities? Is the plant plentiful enough to take a chance on it being receptive to transplanting elsewhere, if need be?

Thank you for the opportunity to review and comment on this draft E.I.S.

Sincerely,

ROBERT K. DODSON
Area Environmental Coordinator



6200-11b (4/74)

United States Department of the Interior

OFFICE OF THE SECRETARY
SOUTHWEST REGION
Room 4030, 517 Gold Avenue SW.
Albuquerque, New Mexico 87102

November 4, 1975

ER-75/930

District Engineer
Corps of Engineers, U.S. Army
Post Office Box 61
Tulsa, Oklahoma 74102

Dear Sir:

This responds to Mr. Weldon M. Gamel's letter of September 12, 1975, referenced SWTED-PE, addressed to the Assistant Secretary--Program Policy, requesting the Department's review and comment on the draft environmental statement for the Red River Chloride Control Water Quality Study, Red River, Texas and Oklahoma.

The statement indicates that control facilities on the North Pease portion of Salt Area IX and at Salt Area XV on the Little Red River are recommended for future development. Further clarification of the status of these facilities would be helpful. It is difficult to tell if the probable impact of these developments is included in the statement.

Comments on specific sections of the draft statement are as follows:

PROJECT DESCRIPTION

During the development of a fish and wildlife report to accompany the Corps' Phase I GDM, the Fish and Wildlife Service was unofficially informed that project lands at the three brine pool areas would be fenced and marked at project cost. If this is correct, it should be so indicated in this section of the statement. Many of the potential beneficial impacts discussed in Section 4 of the statement regarding public access to and use of project lands for recreation would not be likely without the fencing and marking of these lands.

ENVIRONMENTAL SETTING WITHOUT THE PROJECT

Page 2-6. Paragraphs 2.29 and 2.30. The data furnished are not adequate for appraisal of specific ground water impacts. The text indicates that shallow aquifers are variously distributed and not areally of great extent, and a few general details on the occurrence of fresh ground water are given, but these are inadequate for evaluation of impacts. The statement should indicate more specifically the types of spatial and hydraulic relationships that will exist between the proposed saline water impoundments and adjacent fresh water aquifers, springs, and wells. The statement should also highlight any plans or proposals which may be used to minimize chances for further deterioration of potable ground water.

Pages 2-18 and 2-20. Paragraphs 2.81 and 2.91. In order to avoid confusion, it would be well to indicate that the mammals and birds listed as endangered species in these paragraphs are officially listed on the United States List of Endangered Fauna, pursuant to the Endangered Species Act of 1973.

Page 2-25. Paragraph 2.104. The potential Natural Landmark of Estelline Salt Springs, which is now being evaluated by Dr. David Northington of Texas Tech at Lubbock for the National Park Service, lies along the collection pipeline proposed for future development between collection area XV and XIII. The Estelline site may be significant for a relict species of crab that has been extirpated by other work in this area.

PROBABLE IMPACT OF THE PROPOSED ACTION ON THE ENVIRONMENT

Page 4-1. Paragraph 4.01. It is recognized in the statement that the proposed action will degrade rather than enhance water quality in parts of the drainage basin utilized as brine lakes. Any mitigating measures that may be used to minimize this impact should be discussed.

Page 4-2. A suitable map showing locations of river reaches (I-VI) listed in Tables 4-4 to 4-12 should be included in the statement in order to display the distribution of concentrations of selected chemical constituents.

Page 4-7. Paragraph 4.02. It is indicated in the statement that increased lake sedimentation will occur as a result of bank erosion, especially along segments of banks where gypsiferous stringers are associated with soft shales. Any mitigating measures that may be used to minimize this impact should be included.

Page 4-13. Paragraph 4.10. This section indicates that the new water area may be important as a recreation water site because water is short in the region. Even though the evaporation lakes can be expected to expand to a size adequate for water-oriented recreation activities, water quality could be a significant issue affecting recreational use. This aspect should be more fully addressed in the statement.

Page 4-15. Paragraphs 4.16 and 4.17. These paragraphs state that the project is likely to stimulate industrial, residential, and agricultural growth throughout the basin. Changes such as these generally are not compatible with maintaining fish and wildlife production on land and water areas now suitable for such uses. Section 4 should also address the adverse secondary impacts of the project on fish and wildlife populations that result from the expected land and water use changes associated with industrial, residential, and agricultural growth.

ANY PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSAL BE IMPLEMENTED

Page 5-1. Paragraph 5.03. The animals displaced by inundation of habitat in the brine lakes cannot realistically be expected to survive. Surrounding habitat on uplands and escarpments normally will be at or near its carrying capacity and could not support additional wildlife populations for any length of time.

Page 5-3. Paragraph 5.05. Brief mention is made of archeological sites in this paragraph. It would seem appropriate to expand the discussion of probable adverse environmental effects on archeological resources under a separate heading.

Sincerely,

Raymond P. Churan

for Willard Lewis
Special Assistant to the Secretary

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VI
1600 PATTERSON
DALLAS, TEXAS 75201

November 6, 1975

Colonel Anthony A. Smith
District Engineer
Corps of Engineers
P. O. Box 61
Tulsa, Oklahoma 74102

D-COE-G39002-00

Dear Colonel Smith:

We have reviewed your Draft Environmental Impact Statement, the Red River Chloride Control Water Quality Study, Red River, Texas and Oklahoma. The proposed project will include the construction of three lakes for brine disposal. These lakes will inundate approximately 8,000 acres of agricultural land and will facilitate the removal of about 45 percent of the total amount of chloride that presently goes into Lake Texoma.

The following comments are for your consideration in finalizing the statement:

1. Paragraph 4.05, page 4-9, notes, "degradation of soils not covered by lake waters is a probability if waters are withdrawn from the brine lakes for agricultural purposes." Although information is available about the tolerance of various crops to salinity levels, the statement notes, "Use of these saline waters for any irrigation purpose, however, will be at the expense of the general productivity of the soil." We suggest that a water quality monitoring program be implemented to measure salinity levels if the waters from the brine lakes are ever used for the irrigation of crops. Such a program would be beneficial in assuring that the long term general productivity of the area soils is maintained.

2. On page 4-12, paragraph 4.08 states, "Several relocations of negligible environmental proportions will be required by the project. These include county roads, pipelines, and ranch structures." The number of each type facility to be relocated and the extent (length of pipeline displaced, etc.) of the relocations need to be described. Also, the parties responsible for the various relocations should be identified.

3. With regard to secondary environmental impacts of the project, on page 4-12 it is noted that in the region (Lake Texoma and the upstream highly-saline tributaries of the Red River) the availability of better quality water may encourage people to move into the area and may slow down the migration trends out of the area. As a result of this anticipated regional growth, we suggest that potentially adverse secondary effects, such as increased noise, solid waste, air and water pollution, be fully discussed in the statement.

4. Under paragraph 4.12, Project Impacts on Historical and Archeological Sites, paleontological information is mentioned. Paleontological considerations should be included under Geology, pages 2-1 to 2-3, rather than under 4.12.

These comments classify your Draft Environmental Impact Statement as LO-2. Specifically, we have no objections to the proposed project. However, additional information is needed for assessing the total impacts of the project on the environment. The classification and the date of our comments will be published in the Federal Register in accordance with our responsibility to inform the public of our views on proposed Federal actions, under Section 309 of the Clean Air Act.

Definitions of the categories are provided on the attachment. Our procedure is to categorize our comments on both the environmental consequences of the proposed action and on the adequacy of the impact statement at the draft stage, whenever possible.

We appreciate the opportunity to review the Draft Environmental Impact Statement, and we will be happy to discuss our comments with you. Please send us two (2) copies of the Final Environmental Impact Statement at the same time it is sent to the Council on Environmental Quality.

Sincerely yours,

George J. Putnicki

for John C. White
Regional Administrator

Enclosure

## ENVIRONMENTAL IMPACT OF THE ACTION

### LO - Lack of Objections

EPA has no objections to the proposed action as described in the draft impact statement; or suggests only minor changes in the proposed action.

### ER - Environmental Reservations

EPA has reservations concerning the environmental effects of certain aspects of the proposed action. EPA believes that further study of suggested alternatives or modifications is required and has asked the originating Federal agency to re-assess these aspects.

### EU - Environmentally Unsatisfactory

EPA believes that the proposed action is unsatisfactory because of its potentially harmful effect on the environment. Furthermore, the Agency believes that the potential safeguards which might be utilized may not adequately protect the environment from hazards arising from this action. The Agency recommends that alternatives to the action be analyzed further (including the possibility of no action at all).

## ADEQUACY OF THE IMPACT STATEMENT

### Category 1 - Adequate

The draft impact statement adequately sets forth the environmental impact of the proposed project or action as well as alternatives reasonably available to the project or action.

### Category 2 - Insufficient Information

EPA believes the draft impact statement does not contain sufficient information to assess fully the environmental impact of the proposed project or action. However, from the information submitted, the Agency is able to make a preliminary determination of the impact on the environment. EPA has requested that the originator provide the information that was not included in the draft statement.

### Category 3 - Inadequate

EPA believes that the draft impact statement does not adequately assess the environmental impact of the proposed project or action, or that the statement inadequately analyzes reasonably available alternatives. The Agency has requested more information and analysis concerning the potential environmental hazards and has asked that substantial revision be made to the impact statement. If a draft statement is assigned a Category 3, no rating will be made of the project or action, since a basis does not generally exist on which to make such a determination.

OKLAHOMA

GEORGE WINT, ACTING DIRECTOR
GARLAND FLETCHER, ASSISTANT DIRECTOR

**DEPARTMENT OF WILDLIFE CONSERVATION**

1801 N. LINCOLN P.O. BOX 53465 OKLAHOMA CITY, OK. 73105 PH. 521-3851

October 14, 1975

Mr. Weldon M. Gamel
Chief, Engineering Division
Tulsa District, Corps of Engineers
Post Office Box 61
Tulsa, Oklahoma 74102

Dear Mr. Gamel:

This is in reference to the draft environmental statement on the Red River Chloride Control Water Quality Study, Red River, Texas and Oklahoma.

We have reviewed the draft and have no comment in that regard. Thank you for the opportunity to comment.

Sincerely,

George B. Wint
Acting Director

STATE OF OKLAHOMA

# State Grant-In-Aid Clearinghouse

5500 N. WESTERN • OKLAHOMA CITY, OKLAHOMA 73118 • PHONE (405) 840-2811

October 20, 1975

Mr. Weldon M. Gamel
Chief, Engineering Division
Department of the Army
Tulsa District, Corps of Engineers
P. O. Box 61
Tulsa, Oklahoma 74102

RE: 15I507--Red River Chloride Control Water Quality Study

Dear Mr. Gamel:

The environmental information for the above referenced project has been reviewed in accordance with OMB Circular A-95 and Section 102 (2) (C) of the National Environmental Policy Act by the state agencies charged with enforcing environmental standards in the State of Oklahoma.

The state agencies, comprising the Pollution Control Coordinating Board, have reviewed the proposed project. A copy of the comments of Oklahoma Archaeological Survey is attached and made a part of this letter. The state clearinghouse requires no further review.

Sincerely,

Don N. Strain
Director

DNS:sh

cc: SWODA

134-2-1

The University of Oklahoma 1335 South Asp Avenue Norman, Oklahoma 73069

Oklahoma Archaeological Survey

SEP 3 0 1975

September 22, 1975

Mr. Don Strain
Director: State Clearinghouse
4901 N. Lincoln Blvd.
Oklahoma City, Oklahoma 73105

REF: Draft EIS on Red River Chloride Coltrol Water Quality Study, Red River, Texas and Oklahoma. Clearinghouse ID #151507.

Dear Mr. Strain:

We have reviewed the above referenced EIS with reference to cultural and historical sites, which may be affected by the project. It is indicated that while a cursory examination of the project areas have been made; the probability of adverse affect exists. However, the actual on-site survey will not be made till January of 1976. Although such a survey is planned and includes a statement indicating intent to follow up with a mitigation plan, if necessary, I question the filing of an EIS that has not yet taken these things into consideration.

While we do not oppose the projects intent, we do request the Corps account for the total affect the project will have on cultural resources in the project area. At this time it does not appear the Corps has included such consideration or done the necessary field work to do such consideration.

Yours truly,

Don G. Wyckoff

Don G. Wyckoff
State Archeologist

DGW:elr

**OKLAHOMA HISTORICAL SOCIETY**
**Historical Building**
**Oklahoma City, Oklahoma 73105**
**Historic Sites**

October 23, 1975

Mr. Weldon M. Gamel
Chief, Engineering Division
Department of the Army
Tulsa District, Corps of Engineers
Post Office Box 61
Tulsa, Oklahoma 74102

Dear Sir:

It appears that "Jaybuckle Spring," on Elm Creek due north of Reed will be affected by your plans for Area VI, collection pool, Greer County, Oklahoma. No other Oklahoma listed sites appear to be affected.

Although this site is not on the National Register of Historic Places, it is considered a local landmark and was once the headquarters area of an early-day cattle company.

Thank you for allowing this office to review this proposed project.

Respectfully,

G. H. Shirk
State Historic Preservation Officer

cc: Historic Sites Division

# Texas Department of Health Resources

Fratis L. Duff, M.D., Dr.P.H.
Director
Raymond T. Moore, M.D.
Acting Deputy Director

1100 West 49th Street
Austin, Texas 78756
(512) 454-3781



October 24, 1975

Honorable Dolph Briscoe
Governor of Texas
State Capitol
Austin, Texas 78701

ATTENTION: James M. Rose, Director
Division of Planning Coordination

SUBJECT: Draft Environmental Impact Statement
"Red River Chloride Control Water Quality Study,
Red River, Texas and Oklahoma"

Dear Governor Briscoe:

In accordance with a request in a letter from Mr. Wayne N. Brown, of your Office, dated October 2, 1975, the Draft Environmental Impact Statement on the "Red River Chloride Control Water Quality Study" has been reviewed. No adverse public health implications were noted; the findings of the Draft Environmental Impact Statement are consistent with the objectives of this Department.

The project proposes the construction of dams, ponds and other facilities to reduce chloride concentrations in streams in Texas and Oklahoma which are tributaries to the Red River. Texas Department of Health Resources' personnel have been aware of the natural mineral pollution control project near Estelline Springs, Texas, for many years; no adverse public or environmental health effects have been noted at that project.

There are several public water supplies which use surface water sources in the Project Area. No adverse effects on these public water systems are expected to occur as a result of the construction of the proposed brine emission correction facilities. The reduction of the existing natural chloride concentration of waters of the Red River Basin to a level acceptable for municipal, industrial and agricultural uses is considered to be a desirable objective.

The Texas Department of Health Resources concurs with the findings of the Draft Environmental Impact Statement for the "Red River Chloride Control Water Quality Study."

Sincerely,

Fratis L. Duff, M.D.
Director of Health Resources

# TEXAS WATER QUALITY BOARD



PH. (512) 475-2651

1700 NORTH CONGRESS AVE. 78701
P.O. BOX 13246 CAPITOL STATION 78711
AUSTIN, TEXAS

October 24, 1975

Re: Draft Environmental Impact Statement - Red River Chloride Control Water Quality Study Red River Basin

General James M. Rose, Director
Governor's Division of Planning Coordination
Executive Office Building
411 West 13th Street
Austin, Texas 78701

Dear General Rose:

The staff of the Texas Water Quality Board has reviewed the draft environmental impact statement for the Red River Chloride Control Water Quality Study of the Red River Basin and concurs with the findings regarding water quality in the basin under both the present conditions and also under the projected future conditions with the proposed developments installed or constructed. The projected reduction of the average daily load of salts reaching Lake Texoma by approximately 50 percent would be of great enhancement to the water quality of the lake and the nearby streams. It would also be a great enhancement to have the quality of water to be improved in many areas of the basin such that it would be to a suitable chloride level for the municipal, industrial, and agricultural uses most of the time.

The established or approved water quality standards for the various segments of the Red River Basin in Texas were established under the present conditions of the streams and will remain applicable until actual conditions reflect improvements that will justify a revision of the standards. This agency will be pleased to work and cooperate with the sponsors and other interested agencies in developing and carrying out the proposed project. Also since the main stem is an interstate stream requiring interstate cooperation and coordination, this agency will be pleased to cooperate in resolving this aspect of the interstate project.

General James M. Rose
Page Two
October 24, 1975

We appreciate the opportunity to review this project. If we can be of further assistance to you, please let us know.

Very truly yours,

Emory G. Long

Emory G. Long, Director
Administrative Operations

ccs: Col. Anthony A. Smith
TWQB District 1, 2, 4, 5

# TEXAS
# PARKS AND WILDLIFE DEPARTMENT



CLAYTON T. GARRISON
EXECUTIVE DIRECTOR

JOHN H. REAGAN BUILDING
AUSTIN, TEXAS 78701



October 30, 1975

Mr. Wayne N. Brown
Governor's Division of Planning Coordination
Executive Office Building
411 W. 13th Street
Austin, Texas 78701

Dear Mr. Brown:

This Department has reviewed the Draft Environmental Impact Statement "Red River Chloride Control Water Quality Study, Red River, Texas and Oklahoma."

In Section 5, paragraph 5.03 Wildlife Habitat, the statement is made: "Adequate food and cover for the displaced animals will probably be provided by the vegetation of the escarpments and uplands." It is suggested that if the carrying capacity of the adjacent escarpments and uplands is such that it would sustain the population of wildlife which would be added as a result of displacement, such populations would already exist. The displacement of wildlife from the stream beds and reservoir sites onto the adjacent escarpments and uplands will place additional pressure on those food and cover resources to the point of their being over-utilized, thereby resulting in increased deterioration of the habitat and eventual loss of the wildlife.

It is also noted that some wildlife habitat will be permanently lost due to construction activities and inundation. This Department feels that some indirect mitigation for these losses may be gained if the impoundment sites were fenced. It is noted that there is no mention of fencing the brine pools in the document. It is suggested that such activity would render the project more acceptable. This is particularly true if any enhancement projects are undertaken in the future.

Sincerely,

CLAYTON T. GARRISON
Executive Director

CTG:RLC:pm

# APPENDIX B

# LITERATURE CITED

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# APPENDIX B

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SUMMARY ECONOMIC INFORMATION

ECONOMIC DATA EXTRACTED FROM
US ARMY CORPS OF ENGINEERS
GENERAL DESIGN MEMORANDUM
ARKANSAS-RED RIVER BASIN CHLORIDE CONTROL
TEXAS, OKLAHOMA, AND KANSAS
(RED RIVER BASIN)

DESIGN MEMORANDUM NO. 25
GENERAL DESIGN
PHASE I - PLAN FORMULATION

COMPLETE DOCUMENT IS AVAILABLE
AT US ARMY ENGINEER
DISTRICT, TULSA, OK

PROPOSED RED RIVER CHLORIDE CONTROL DATA

SUMMARY OF TANGIBLE BENEFITS
(July 1976 Prices)

| | |
|---|---|
| Water quality | $ 17,317,200 |
| Redevelopment | 48,600 |
| Total | $ 17,365,800 |
| TOTAL FIRST COST | $124,000,000 |
| Annual Costs (Includes interest and amortization, operation and maintenance, and replacements) | $ 8,025,000 |
| Benefit-to-cost ratio | 2.2 |

# STATEMENT OF FINDINGS

## ARKANSAS-RED RIVER BASIN CHLORIDE CONTROL
## TEXAS, OKLAHOMA, AND KANSAS
## (RED RIVER BASIN)

1. Purpose. I have reviewed and evaluated, in light of the overall public interest, the material which concerns the various feasible alternatives for solving the water quality problems and needs of the Red River Basin. I have also considered all other relevant material available as well as the view of other interested agencies in forming my conclusions and recommendations. Part II of the Red River Chloride Control project (Areas VI, IX, XIII, XIV, and XV) was authorized for construction by the Flood Control Act of 1970 (Public Law 91-611) to control natural salt pollution from sources in the upper Red River Basin. The action proposed in this general design memorandum would provide the project purpose in the authorization act.

2. Methodology. A number of alternatives were developed which would solve to varying degrees the problems and needs disclosed by investigations. In my review, I have examined the possible consequences of the various alternatives, including environmental effects, social well-being, economic effects, regional and natural economic development, and engineering feasibility. The consequences noted have been compiled from special studies conducted by other State and Federal agencies, and from the public. Views of the public were obtained at public meetings and public workshops. Meetings were held in Vernon and Denison, Texas, on 15 and 16 October 1975, respectively, and in Shreveport, Louisiana, on 17 October 1975. Public workshops were held in Mangum, Oklahoma, on 26 August 1974; at Childress, Texas, on 27 August 1974; at Vernon, Texas, on 29 August 1974; at Shreveport, Louisiana, on 5 September 1974; at Wichita Falls , Texas, on 10 September 1974; and at Denison, Texas, on 11 September 1974. Public response has generally been favorable, although some opposition was expressed by affected landowners and by individuals concerned about possible contamination of ground water in the vicinity of control structures.

3. General alternatives. Alternatives considered for achieving lower concentration of chlorides in the Red River Basin are of two types: general system-wide plans and specific plans for each salt emission area.

a. System plans. The overall strategies considered for accomplishing the authorized project purpose are discussed below.

(1) Pipeline to Gulf of Mexico. This alternative consists of collection systems at the salt source areas, a main trunk pipeline with intermediate pump stations spaced to pump the brine to the Gulf of Mexico, and pump stations to transport the brine from the collection areas to the main trunk pipeline. The pipeline would be approximately 480 miles long, and 52 pump stations would be required. This alternative was eliminated from further consideration because of its excessive cost ($1,000,000,000

first cost and $17,000,000 annually), high energy requirements, and lengthy construction time. It also posed a possible threat to coastal marine life in the Gulf.

(2) Importance of water for dilution. This alternative provides two choices. The first choice is a series of impoundments on high quality streams downstream of Lake Texoma with a system of canals and pump stations to transport the water to Lake Texoma for dilution of brine flows. The second choice is a system of freshwater lakes upstream of Lake Texoma to release water for dilution. Construction of upstream lakes is not feasible as the streamflow and rainfall pattern of the region is too erratic to produce an adequate supply of dilution water. Construction of the downstream system would generate legal and political problems related to interbasin transfers, transportation costs, use of the water, and management arrangements. Because of these problems, the alternative was abandoned.

b. Specific plans. The alternative plan for each source area consists of a collection system and a disposal system. Collection and disposal systems are described below and their application to each source area is discussed in paragraph 4.

(1) Collection systems. The five types of collection systems studied in detail were subsurface cutoff walls, low flow dams, wellpoints, shallow wells, and total impoundment. The subsurface cutoff wall system consists of a concrete wall down to bedrock and a perforated collection pipe with lateral infiltration lines situated so that the drain pipe produces a gravity flow to a sump, from which brine is pumped for disposal. Low flow dams impound flows which are drained into a sump and pumped to a disposal system; the dams would have a deflatable weir section which would allow floodflows to pass unimpeded. The third alternative consists of a system of wellpoints designed to collect subsurface brine flows by suction and pump them to a sump by a collection header pipe; from the sump, the brine would be pumped to the disposal facility. The fourth alternative is a system of shallow wells drilled 5 to 10 feet into bedrock in the salt emission areas. Submersible pumps in the wells would collect the brine flows in the top of the bedrock and pump them through a common header pipe to the disposal system. The total impoundment alternative consists of a dam located on the stream below the chloride source, designed to retain an accumulation of 100 years of brine runoff and a 100-year flood.

(2) Disposal system. Three alternatives were considered for brine disposal, including brine impoundment lakes, deep well injection, and desalination. Brine impoundment lakes consist of an impervious dam to impound the brine water and serve as an evaporation lake. Deep well injection systems would consist of pumping treated brine down wells drilled into geologic formations known to possess adequate porosity and permeability. Desalination would utilize advanced water treatment processes to remove the chlorides from the brines collected.

c. No action. The alternative of postponing indefinitely any construction of a chloride control system was also considered. This alternative would eliminate any adverse social or environmental effects associated with the construction and operation of control systems. However, it would forego the water quality improvements and resultant economic and social benefits that construction of the project would provide.

4. Area alternatives. The collection and disposal system alternatives described in paragraph 3(2)b were applied to each source area in various combinations to yield the selected plan.

a. Area VI. Six alternative collection and disposal plans were considered for Area VI. Plan A would consist of subsurface cutoff walls in each of the three canyons where salt sources are located, with collected brine being transferred for disposal to a 2,500-acre brine dam on Fish Creek. Plan B differs from Plan A only in the location of the brine dam on Fish Creek and provisions are made for additional brine flows to be captured from the Elm Fork. Plan C also is similar to Plan A, except that the brine dam is located on a north bank tributary approximately 4 miles downstream from Fish Creek. Plan D would use the same collection system as the previous plan, but would employ a deep well injection system for brine disposal. Plan E would use the same collection system as the previous plans, including a brine dam for storage at the Fish Creek site proposed in Plan A, but would add a desalination process for disposal of brines. Plan F would consist of a low flow dam on the Elm Fork River for collection of brines and a brine dam at the Fish Creek site for disposal. Estimates of costs were made for the different plans at various chloride removal rates. Plan D proved to be the most cost effective in terms of tons per day removed per dollar of annual cost. Plan C was the least cost effective at all removal levels.

b. Area IX. Seven alternative collection and disposal systems were considered for Area IX. Plan A would require two subsurface cutoff walls below each of the salt sources on the Middle Pease and North Pease Rivers for collection and a 4,900-acre brine evaporation lake on Canal Creek for disposal. The evaporation lake is approximately 21 miles from the collection site which was the nearest site with suitable geologic conditions. Plan B would have also used subsurface cutoff walls but was eliminated because no suitable subsurface storage zone was available locally for injection. Plan C would utilize four to 10 wellpoint collection systems located near each salt source area and the evaporation lake described under Plan A. Plan D would consist of low flow dams on the North and Middle Pease Rivers, with the same disposal system described in Plan A. Plan E which would have utilized a total impoundment dam on the Pease River to control all chlorides from Area IX was eliminated from further study because a dam at the nearest possible site would have been prohibitive in cost and created leakage problems. Plan F would have employed a 2.3 to 10.8 m.g.d. plant to desalt the brines but was eliminated because preliminary estimates showed it to be prohibitively expensive. Plan G would consist of a shallow well collection system and the same disposal system as discussed in Plan A. With Plans B and F eliminated, Plan G would have the lowest annual cost per ton of chloride removed per day at all removal levels, and Plan A would have the largest.

c. Areas XIII and XIV. Eight plans were considered for chloride removal at Areas XIII and XIV. Plan A would consist of subsurface cutoff walls at each source area (including the existing Jonah Creek experimental project) and a 1,400- to 2,500-acre brine evaporation pond on Dry Salt Creek. Plan B would consist of a wellpoint collection system and the existing Jonah Creek system, with a brine impoundment lake similar to the one proposed in Plan A. Plan C would employ a low flow dam at each source area in addition to the existing Jonah Creek collection system and the brine impoundment lake discussed in the two previous plans. Plan D would use the same subsurface collection system described in Plan A, with six injection wells (including the existing Jonah Creek well) as the disposal system. Plan E would use the same collection system as Plan A, with a desalination process used for disposal. Plan F would utilize a shallow well collection system in addition to the existing Jonah Creek collection system, and the brine impoundment lake discussed in Plan A. Plan G would use the same collection system as Plan F, with deep well injection for disposal. Plan H would use the same collection system as Plan F, with disposal of brines in Crowell Brine Dam. Cost-effectiveness studies showed Plan G to have the lease annual cost per ton of chloride removed per day at all levels of control, and Plan A to have the highest annual cost plan but the lowest level of control.

d. Area XV. Seven alternative control systems were considered for Area XV. At the higher levels of control, Plan A would utilize a subsurface cutoff system at each salt source. At the lowest levels of control, a subsurface cutoff system would be used at only the downstream source. The disposal system for either control level would be a brine impoundment lake on Oxbow Creek. Plan B would consist of a system of six to 16 wellpoint collection systems at one or both source areas, depending on the level of control, and the brine impoundment lake described in Plan A. Plan C would utilize a low flow dam at the downstream source area for lower levels of control, or a low flow dam at each source area for higher control levels, with the brine impoundment lake of Plan A. Plan D would have the subsurface collection system described in Plan A, with a deep well injection system of eight wells for disposal. Plan E would employ a 3,600-acre total impoundment lake on the Little Red River below the source areas. Plan F would use the same collection system as Plan A, with a desalination process for brine disposal. Plan G would collect brine with a combination of subsurface cutoff walls at the mouths of Bluff and Lost Mule Creeks and on the Little Red River and shallow wells upstream of the cutoff walls. Disposal would be at Crowell Brine Lake. Cost studies showed Plan D to have the lowest cost per ton of chloride removed per day at a lower level of control, but its cost was the highest of any of the plans at the highest level of control. Plan C showed the highest cost for low control levels, but was third highest at high levels. Plans A and B were in the intermediate range. The costs of Plans E and G could not be compared with the other plans at all levels of control as their costs were estimated at only one control level.

5. Plan selection procedure. Three of the alternatives were screened from further consideration due to high costs, environmental effects, or

political and legal implications. These were the pipeline to the Gulf, water importation for dilution, and desalination. The desalination process would yield a brine effluent which would require a secondary disposal method, and first costs and operating costs were not competitive with other alternatives. In addition, the plants must be replaced approximately every 20 years and operate in the general cost range of $1.00 per thousand gallons according to the Office of Saline Water Report "Status of Desalting." Other alternatives were found to be technically infeasible or environmentally unacceptable at certain source areas. At Area IX, deep well injection was eliminated because no suitable geologic formation for disposal was available in the areas, and total impoundment was eliminated because geologic conditions would allow brine water to contaminate ground water. The remaining alternatives were subjected to economic, environmental, and social effects investigations to determine the most acceptable alternative for each area. At Area VI, Plans A and C were eliminated because of their high cost. Plans D and F had low costs but both plans included deep well injection. Some questions exist regarding brine disposal by deep well injection. Long-term projections of the storage capacity of the disposal zone are somewhat uncertain. Computations are based on conditions at the well bore and from exploratory wells drilled in the project vicinity. However, the geologic formations evaluated at the disposal zones may not be uniform over a wide areal extent. Therefore, Plan B was selected as the recommended plan. At Area IX, Plan B was eliminated because it included deep well injection and studies indicated no adequate subsurface formation for deep well injection in the area. Plans A, C, and D were eliminated because they offered no more benefits than Plan G and at a higher cost; therefore, Plan G is the recommended plan. At Areas XIII-XIV, Plans D and G included deep well injection and were eliminated because of the high volume of flow and relatively low concentration of brine. In addition, high volume flow rates could exceed the estimated storage capacity of the subsurface formation within the proposed project life. Plans A, B, C, and F were more expensive than Plan H but offered no additional benefits; therefore, Plan H is the recommended plan at Areas VIII-XIV. Then optimization studies were conducted with the recommended plan at each area to determine the overall plan and level of control that would yield the maximum economic benefits. Optimization studies showed that development of Area XV is not incrementally justified at this time. The final plan selection made substantially satisfies the water quality objectives set forth in the authorizing documents.

6. Selected plan. The plan selected is economically feasible and would yield the best quality water to accomplish the authorized project objectives. In addition to the Wichita River project, the selected plan would consist of four parts. The first is a subsurface collection system with a brine dam to control 420 of the 510 tons per day of chlorides from Area VI. The second is a system of shallow wells with disposal at Crowell Brine Dam to control 190 tons of the 342 tons per day at Area IX. The third is a shallow well collection system with disposal at Crowell Brine Dam to control 500 of the 570 tons per day of chlorides at Areas XIII and XIV. The fourth is to forego development of a control system at Area XV until such future time as development becomes economically feasible and socially and environmentally acceptable.

7. Rationale for selected plan.

a. General. In evaluation of the selected plan and other viable alternatives, the following points were considered pertinent.

b. Environmental. The biological, archeological, paleontological, historical, and economic effects of each alternative were reviewed to determine their impacts on the existing environment, and consideration was given to these effects in the selection of the proposed plan. Trade-offs between possible adverse environmental effects in the selected plan and the alternatives with the other accounts of social well-being and regional and national economics were unavoidable. The recommended project has the best mixture of those trade-offs.

c. Social well-being. The effects on people, both those in the immediate vicinity of the project and those depending upon the project for water quality improvement, were considered in the analysis of the alternatives.

d. Engineering. Sound engineering principles were used in the development of alternative solutions to the water resource needs in the Red River Basin. Various measures were developed, evaluated, and incorporated in the plan selection studies to determine the recommended plan.

e. Economics. The costs and benefits of each alternative solution were evaluated. The proposed project realizes the maximum benefits and is consistent with the desires of local interests.

8. Findings. I find that the action proposed in this memorandum is based on thorough analysis and evaluation of various practicable alternative courses of action for achieving the stated objectives. I also find that whatever adverse effects are found to be a part of this plan are unavoidable by following reasonable courses of action which would achieve the congressionally specified purposes. In addition, where the proposed action has an adverse effect, this effect is either ameliorated or substantially outweighed by other considerations of national policy. The recommended action is in accordance with national policy, statutes, and administrative directives, and on the whole, I feel the total public interest would best be served by the implementation of the selected plan.

13 Aug 76
Date

Anthony A. Smith
ANTHONY A. SMITH
Colonel, CE
District Engineer

Arkansas-Red River Basin Chloride Control
Texas, Oklahoma, and Kansas
(Red River Basin)

I concur in the preceding Statement of Findings.

16 August 1976
(Date)

Charles I. McGinnis
CHARLES I. McGINNIS
Major General, C.E.
Division Engineer

I concur in the preceding Statement of Findings.

10 May 1977
(Date)

Drake Wilson
DRAKE WILSON
Brigadier General, USA
Deputy Director of Civil Works